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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B62K 25/28

A1

(11) International Publication Number: WO 96/09203

(43) International Publication Date: 28 March 1996 (28.03.96)

(21) International Application Number: PCT/US95/11932

(22) International Filing Date: 20 September 1995 (20.09.95)

(30) Priority Data:
309,331 20 September 1994 (20.09.94) US

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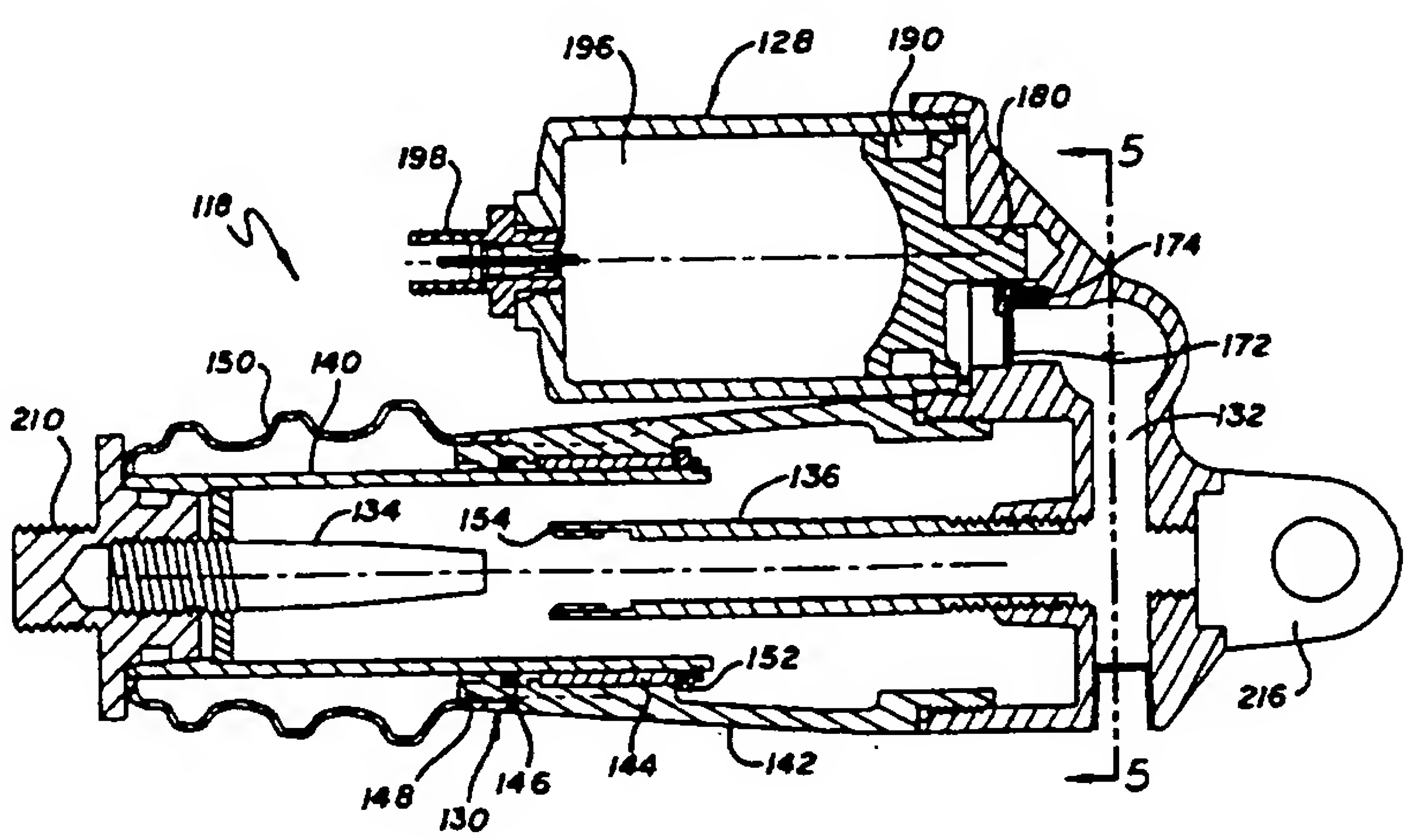
(81) Designated States: AU, BR, CA, CN, JP, KR, MX, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: BICYCLE SUSPENSION SYSTEM AND SHOCK ABSORBER THEREFOR



(57) Abstract

A shock absorber device (118) for bicycle rear wheel (106) suspensions and mounted operatively between the bicycle frame (102) and rear wheel (106). It includes a barrel valve (156) having variable width slots and/or at least one (indexed) hole wrapped around it and a shim (or reed) valve. The valve controls the hydraulic flow through those slots dependent upon whether it is the compression or return stroke and if the compression stroke whether it is in a high or low compression. The barrel valve can be rotated to reposition the slots relative to the shim valve (172) and thereby controllably vary the hydraulic resistance of the shock absorber between locked off, full on and a continuum of conditions therebetween. The barrel valve is adjusted by a handle (122) mounted directly on the device or a shifter mounted on the handle bars. Thereby the rider can adjust the hydraulic resistance of the shock absorber while he is riding the bicycle as riding conditions may warrant. The hydraulic resistance acts upon a pneumatic or (return) (internal or external) spring dampener whose pressure may be adjusted by the rider as desired riding the bicycle.

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BICYCLE SUSPENSION SYSTEM AND SHOCK ABSORBER THEREFOR

Background of the Invention

The present invention relates to suspension systems for bicycles and the like. It more particularly relates to rear shock absorber systems for bicycles and those shock absorbers which have hydraulic means for dampening an air spring motion. It further is concerned with those shock absorbers which can be readily adapted by the consumer and mounted to most bicycles and particularly all-terrain and mountain bicycles.

Many bicycles today have suspension systems which are particularly useful when riding down hill to keep the bicycle wheels on the ground. The suspension system absorbs the bumps and helps the bicycle suspension track the ground. This makes the bicycle handle better for off-road riding at fast speeds. Suspensions can markedly increase the control the rider has of his bike especially when cornering. They reduce the shocks to which riders are subjected when riding over rough terrain.

Suspension systems, while invaluable for down hill riding, are disadvantageous for most riding situations. They reduce pedaling efficiencies, absorbing energy. Thus, in the past, many serious bicyclists would have two bikes -- a rigid one and a suspended one -- for different racing or riding conditions.

Bicycle frames which can be converted, before the rider begins riding, between suspension and rigid configurations have thus been developed. An example of one is "The Convertible" available from Morales Mountain Bike Co. of Fountain Valley, California. Disadvantages of this system are the need for removal and replacement of the shock with a rigid member.

When riding over varying terrains it is usually desirable for the rider to be able to switch between rigid and suspended systems without stopping the bike. Only one system is known for doing this and this is described in U.S. Patent 4,582,343 (Waugh). The shock absorber of Waugh has its outer housing incorporated as a rigid structural element of the triangulated main frame. This means that it cannot be adapted to be used on existing bikes; it cannot be an after-market type of product. It also is adjustable only between fully locked and unlocked modes, not allowing for user selection between different amounts of shock absorption.

Examples of other patented bicycle (or motorcycle) suspension or shock absorber systems are disclosed in U.S. Patents 4,735,276 (Burton), 4,295,658 (Kashima), 4,515,384 (Honma et al), 4,964,525 (Kawamura), 5,186,481 (Turner), 4,971,344 (Turner), 4,815,763 (Hartmann), 4,881,750 (Hartmann), and 4,440,413 (Miyakoshi et al). All of the patents and other publications mentioned anywhere in this disclosure are hereby incorporated by reference in their entireties.

Summary of the Invention

Directed to achieving the above objects, disclosed herein is an improved bicycle rear wheel suspension system, which includes an air spring-loaded hydraulic shock absorber, using preferably ten-weight hydraulic oil as the hydraulic fluid. The shock absorber is a component separate from the triangulated bicycle frame. It has a length of five inches for the two-axis configuration and seven inches for the single-axis configuration, and a weight of 9.5 ounces. It thereby adds little weight to the bike and is compact enough to be fitted on nearly every bike. It can be easily mounted (as an after-market product) to nearly all existing bikes, operatively between the frame and rear

wheel. When mounted and operated it dampens the transmission of the up-and-down impact motion of the rear wheel through the frame to the seat and handle bars, and thereby to the rider. A control mechanism accessible to and operable by the rider allows the rider to adjust the shock absorber resistance between off and on and a continuum of conditions therebetween, while the rider is riding the bicycle, to adjust for different terrains and other riding conditions. This mechanism can be mounted directly on the shock absorber as a turn handle or on the handle bars as a thumb or twist actuator and then operatively communicate through a cable to the shock absorber. A return spring disposed within the shock absorber housing is provided for cable tensioning and return of the cable (similar to throttle return springs).

The shock absorber includes a hydraulic piston having a galleyway at its head and into which the hydraulic fluid is pushed by the piston during the compression stroke, as when the rear wheel runs over a bump. A valve system determines whether the fluid from the galleyway passes to the head end of the spring for urging against the spring and thereby dampening the compression force. It is thus the valve system which can be rider-adjusted among the different resistance conditions. The piston includes a metering pin arrangement which dampens the shock at the end of the stroke.

The valve system includes a cantilevered shim or reed valve, which gradually opens as the compression pressure in the galleyway increases, and a barrel valve. The barrel valve has at least one slot whose effective through-flow cross-section changes at different locations about the circumference of the cylindrical barrel thereof. As the barrel is rotated the portion of the slot in fluid communication with the shim valve changes and thus the effective slot size changes. Rider operation of the control mechanism causes the barrel to rotate to the desired

effective slot size position, and thereby the desired level of hydraulic resistance.

Preferably three slots are formed in the barrel, each spaced longitudinally from the other and each extending circumferentially about between five percent and thirty-thirty percent around the barrel and having variable effective opening sizes. The shim valve has one constantly open opening which always communicates with the third of the three barrel valve slots, which itself has a very small opening. With no compression fluid force in the galleyway the shim valve blocks the first and second slots and with increasing fluid force it opens them accordingly. The cantilever mounting of the shim valve is such that it takes more force to open the second slot than the first and third slots.

The second slot has the largest opening, followed by the first and then the third. Thus, during low speed compression the shim valve does not open the second slot and oil flows only through the first and third slots. On the other hand, during high speed compression (when the bike hits a hard shock) oil flows through all three slots. However, most of this flowing oil flows through the second slot because it is the largest. Then during the return or rebound, oil flows only through the third slot, through the through-opening in the shim.

According to one shock absorber design (a dual-axis design) the axis of the spring is offset from and parallel to the axis of the hydraulic piston. In this design the shim valve is between the barrel valve and the galleyway. On the other hand, another design (a single-axis design) has the axes of the spring and the hydraulic piston aligned. In this single-axis design the barrel valve is positioned between the shim valve and the galleyway. More particularly, the oil flows from the primary chamber, to the shim valve, the barrel valve, and the hydraulic cylinder to the air spring. This difference in the relative positioning

of the shim and barrel valves between these two designs is because space considerations of the single-axis design. The dual-axis design, wherein the barrel valve is before the shim and thus is the controlling feature, is the preferred design.

The spring is preferably an air spring having an accumulator piston against which fluid through the valve system acts for pushing the piston against the air in an accumulator chamber. A valve communicating with the chamber allows the user, using a pump, to adjust the air pressure in the chamber so that the spring weight corresponds to his body weight and the shock deflects slightly with his weight on the bicycle.

Other objects and advantages of the present invention will become more apparent to those persons having ordinary skill in the art to which the present invention pertains from the foregoing description taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a side elevational view of a bicycle including a shock absorber device of the present invention mounted thereon;

FIG. 2 is an enlarged side elevational view of the (dual-axis) shock absorber device of the bicycle of FIG. 1, illustrated in isolation and in a relaxed condition;

FIG. 3 is a view similar to FIG. 2 illustrating the shock absorber device in a compressed condition;

FIG. 4 is a longitudinal cross-sectional view of the shock absorber of FIG. 2;

FIG. 5 is an enlarged cross-sectional view taken on line 5-5 of FIG. 4;

FIG. 6 is a view taken on line 6-6 of FIG. 5;

FIG. 7 is an enlarged elevational view of the shim valve element of FIG. 5 illustrated in isolation;

FIG. 8 is a view similar to FIG. 5 but with the spring (which is used to return the cable), the valve body mount, and the barrel valve elements omitted for clarity and to better illustrate the shim valve and its location in the valve body mount;

FIG. 9 is a view taken on line 9-9 of FIG. 8;

FIG. 10 is a cross-sectional view of the shock absorber of FIG. 3 shown in isolation similar to FIG. 4;

FIG. 11 is an enlarged perspective view of the barrel valve of FIG. 5 illustrated in isolation;

FIG. 12 is a schematic diagram of the hydraulic and pneumatic circuit of the shock absorber of FIG. 2;

FIG. 13 is an enlarged front perspective view of the top portion of the bicycle of FIG. 1 showing a cable shifter mechanism thereon;

FIG. 14 is a side elevational view of the shock absorber of FIG. 2 showing a control cable connected thereto;

FIG. 15 is an enlarged side elevational view of an alternative embodiment of the shock absorber of FIG. 1, having a handle mounted adjuster;

FIG. 16a is a chart showing data of a barrel valve of the shock absorber of FIG. 2, showing orifice diameter data for the purpose of designing slot configurations and sizes;

FIG. 16b is a graph showing compression time for the barrel valve described in FIG. 16a;

FIG. 16c is a graph showing differential pressure for the barrel valve described in FIGS. 16a and 16b;

FIG. 17 is a side elevational view of a second bicycle of the present invention showing an alternative mounting arrangement of the shock absorber device of FIG. 2;

FIG. 18 is an enlarged top plan view of the shock absorber strut assembly of the bicycle of FIGS. 1 or 17, illustrated in isolation;

FIG. 19 is a side elevational view of a third bicycle of the present invention illustrating another alternative mounting of the shock absorber device;

FIG. 20 is an enlarged top plan view of an alternative (single-axis) shock absorber device of the present invention;

FIG. 21 is a side elevational view of the shock absorber device of FIG. 20;

FIG. 22 is a longitudinal sectional view of the shock absorber device of FIG. 20 illustrated in a relaxed condition;

FIG. 23 is a view similar to FIG. 22 illustrating the shock absorber device in a compressed condition;

FIG. 24 is an enlarged cross-sectional view taken on line 24-24 of FIG. 23;

FIG. 25 is a view taken on line 25-25 of FIG. 24;

FIG. 26 is a hydraulic/pneumatic circuit diagram of the shock absorber device of FIG. 20;

FIG. 27 is an elevational view showing an alternative use of the shock absorber device of FIG. 2 on a conveyor system; and

FIG. 28 is a view similar to FIG. 27, illustrating an alternative (conveyor system) use of the shock absorber device of FIG. 20.

Detailed Description of the Preferred Embodiments

A bicycle of the present invention is shown generally at 100 in FIG. 1. It includes a frame 102, a front wheel 104, a rear wheel 106, a handle bar 108, a seat 110, pedal 112, and a drive chain 114. Mounted between the frame 102 and the rear wheel 106 is a shock absorber device of the present invention shown generally at 118, which is secured at one end to the frame below the seat 110 and at its opposite end to a strut assembly 120. The strut assembly 120 is then secured at the opposite ends to the rear wheel

106 as will be described later. The hydraulic resistance of the shock absorber 118 can be controlled by a control mechanism 122 mounted on the bicycle handle bars 108 and operatively communicating through a cable 124 with the shock absorber.

The shock absorber 118 is shown in isolation in FIG. 2 in a relaxed condition and in FIG. 3 in a compressed condition. The internal components are illustrated in the cross-sectional views of FIGS. 4, 5, 8 and 10. Referring to FIGS. 4 and 10, it is seen that the shock absorber 118 includes an accumulator piston arrangement as shown generally at 128, a hydraulic piston arrangement shown generally at 130 and a pathway system shown generally at 132 communicating the hydraulic fluid from the hydraulic piston up to the accumulator piston arrangement. The hydraulic piston arrangement 130 includes a compression control pin 134 which is spaced out from a transfer tube 136 when the shock absorber device 118 is in the relaxed condition and when in the compressed condition, it is fully inserted thereinto, as can be understood by comparing FIGS. 4 and 10.

The compression control pin 134 is mounted to a cylindrical shaft 140 which is fitted with a snug fit into the inside of the housing 142 and when in a shock condition it is pressed into the housing; that is, it is pressed from left to right in the figures. It travels on bearings 144 and the fluid in the cylinder is kept therein by a primary seal 146. A wiper 148 having a set of sharp lips scrapes dirt and the like off of the shaft 140, keeping it clean. A flexible bootie 150 protects it from dirt and the like. A snap ring 152 at the end of the shaft 140 prevents the shaft from sliding completely out of the housing 142 on the return stroke. The shaft 140 of the housing 142 thus is a linear sliding shaft and is sealed with hydraulic seals such that oil cannot weep out and such that during the compression stroke, all pressure is held internally. As the

shaft 140 is pushed in, oil is deflected and travels up the transfer tube 136.

The compression control pin 134 has a unique cylindrically tapered or conical shape to control the equivalent flow orifice area into the transfer tube 136. The transfer tube 136 is secured inside and in the center of the housing 142 as by threading thereinto. At the end of the transfer tube 236 is a pressed-fit cap 154 of nylon, Teflon or some other non-marring material, to prevent the transfer tube from scraping against the compression control pin 134 during the movement of the control pin in and out of the transfer tube.

The compression control pin 134 travels into the transfer tube 136 so as to shut the oil off during the compression stroke. In other words, at the beginning of the stroke, the compression control pin 134 travels towards but outside of the transfer tube 136 and the oil is thus free to flow into the transfer tube. Then the control pin 134 slips into the transfer tube 136 and the maximum fluid flow orifice is thereby controlled, controlling the flow of oil. As the shock gets up to speed, the flow is bled down and the movement of the control pin 134 is decelerated at the end of the stroke. That is, there is controlled deceleration at the end of the stroke due to a decreasing orifice area into the transfer tube 136. FIG. 10 shows the control pin 134 completely in the transfer tube 136 and thereby shutting the flow of oil off at the end of the stroke. Thereby the shock absorber 118 will not bottom out or come to a mechanical bottom, and a hydraulic cushion at the end of the stroke is provided. This is similar to what is done in industrial linear actuators, such as described in the article entitled "The Great Shape" from Parker FluidPower. The control pin 134 can be designed by first determining the desired performance of the shock absorber 118, that is, the orifice area that would allow fluid to flow with the desired

pressures, and then configuring the control pin to provide for the required equivalent orifice areas.

The oil flowing out of the transfer tube 136 during the compression stroke passes up to a barrel valve as shown in FIG. 5 or in isolation in FIG. 11 generally at 156. The barrel valve 156 is approximately ¾ inch long. It has three slots or grooves 160, 162, 164 on the outside diameter thereof to control the maximum fluid flow relative to the rotary position thereof. The barrel valve 156 fits into its cylinder 170 itself with a very close tolerance of approximately plus or minus .0005 inch, close enough as to not require any seals to achieve a lock. During the compression stroke, the fluid is routed via the barrel valve 156 to a fiberglass cantilevered shim (or reed valve), which is shown in isolation in FIG. 7 generally at 172. The shim 172 is held in position either by a bolt (or screw) 174 through shim opening 176 or by the cylinder 170 and covers the three orifices 160, 162, 164 of the barrel valve 156 on one side thereof. The shim 172 acts similar to a check valve, but without any mechanical pieces. During the compression stroke, the three orifices 160, 162, 164 are all exposed, as discussed below, to the shim 70 allowing fluid to flow through all three of them. That is, all three are passing fluid through the barrel valve 156. On the return stroke though, the fluid is routed back through only the third orifice 164.

Referring to FIG. 11, the positionings, shapes and configurations of the three slots or grooves 160, 162, 164 are best illustrated. The first groove 160 is a low-speed compression groove supplying fluid for force metered flow; the second groove 162 is a high-speed compression slot supplying force metered flow; and the third groove 164 is a primary compression or rebound slot. As the barrel valve 156 is rotated, relative to a plane through its axis, the cross section of fluid flow area varies depending upon the rotary position. In other words, each groove or slot 160,

162, 164 defines a variable cross-section orifice positioned circumferentially or wrapped around the cylindrical barrel valve surface 178.

During a high-speed compression stroke, such as a hard shock, all three slots 160, 162, 164 are allowed to flow oil, but the flow through the second slot 162 is the greatest, because it offers the least amount of resistance due to its wide large slot opening. At its widest area it has an opening of approximately .156 inch in diameter. The shim valve 172 is a non-linear shim due to its cantilevered mounting, requiring a larger amount of force through the barrel valve 156 to open the middle slot 162 than the outer two slots 160, 164. The ends of the shim 172 are somewhat loose relative to the center or the high-speed compression port 162 where it is a relatively stiff position on the shim. That is, the smallest amount of deflection from the fluid force against the shim occurs at the location of the high-speed compression port 162. During the compression stroke, the third slot 164 does not flow much oil because of its small opening. But on the return stroke, it is the only orifice allowed to flow oil because the shim valve 172 blocks off the first and second grooves 160, 162; that is, it is an opening 182 through which oil passes on the return stroke. Using one of the barrel valve slots as the return path is more efficient than providing a separate check valve. This is because the extra costs of and space for a check valve are not needed. Also, the small return orifice 164 allows for a smooth gradual return of the hydraulic piston arrangement 130 from its position of FIG. 10 to that of FIG. 4.

In other words, the shim 172 acts as a check valve or a reed valve as oil forces it to deflect thereby creating an open passage dependent upon the pressure exerted thereon during the compression cycle stroke of the shock absorber 118. During the return stroke, the oil pressure causes the shim 172 to be pushed against the orifices 160, 162, thereby

blocking them. This is similar to a diaphragm-style check valve used in many pumping systems and, in fact is similar to the human heart valve. Instead of the present shim or reed valve 172 with its flappy cantilevered ends, any similar assembly that creates a similar valving can be used as would be apparent to those skilled in the art. For example, instead of grooves or slots, indexed holes can be used wherein a set of orifices (holes) are placed radially through the barrel valve and timed to the passages in the body. Flow can then be controlled by check valves or pilot-operated check valves.

The barrel valve 156 is somewhat similar to barrel valves used on diesel and high performance fuel injection systems in that it has a slot or groove on the outside diameter (178) that controls the maximum fluid flow relative to the rotary position. During the compression stroke, the fluid is routed through the barrel valve 156 to the shim 172 which acts as both a variable orifice and a check valve. Return damping is achieved by restricting the fluid to one slot 164 in the barrel as the shim 172 blocks the other two passages in the valve body. The shock absorber 118 is throttled to a complete hydraulic lock by the connection of the barrel valve 156 to the thumb actuated lever 122 via the cable 124, as described later. The barrel valve 156 thus includes (1) the low-speed compression groove 160 which provides fluid to the secondary control port and has an operational range of thirty to ninety degrees, (2) the high-speed compression slot 162 which provides fluid to the high-speed compression port and has an operational range of ten to ninety degrees, and (3) the primary control groove 164 which provides fluid to and from the primary control port and has an operational range of zero to ninety degrees.

It takes a large amount of force to open the second orifice 162 so that it starts flowing oil. Thus, during a slow compression, when the rider is just bouncing along on his bike, only the first and third slots 160, 164 are

flowing oil. However, when the bicycle hits a large bump and an acceleration greater than two g's is exerted on the shock absorber 118, the second slot 162 is opened. But in normal situations, the shim valve 172 is only deflecting on and opening the first and third ports 160, 164.

Thus, during the initial stages of a shock, the oil is completely free to flow; then as the pin 134 steps into the transfer tube 136, the maximum orifice through which the oil can flow is controlled. The shock absorber 118 gets up to speed and then it is bled down, decelerated at the end of the stroke. The barrel valve 156 controls the maximum orifice areas and the compression pin 134 decelerates it at the end of the stroke. At the end of the stroke on the return cycle, a return metering pin 180 at the end of the accumulator piston 190 provides a hydraulic cushion when the shock absorber returns to the fully relaxed state. Thus, fluid flow control is provided at the beginning, the middle and the end of the shock absorbing stroke.

The accumulator body portion 192 is a separate modular component which can be threaded into the rest of the housing of the shock absorber 118. It houses the accumulator piston 190 which is the primary energizer for the air spring. That is, the accumulator piston arrangement 128 is simply an air spring that receives the air fluid, compresses it so the pressure rises and then it pushes it back. The accumulator piston 190 travels within the accumulator body 192 with a tight fit having seals 194 around the circumference, sandwiched between the piston and the body, to prevent the hydraulic fluid from leaking into the accumulator chamber 196 and similarly the air in the accumulator chamber from leaking into the hydraulic fluid.

The amount of the pressure in the chamber 196 can be adjusted to charge the shock absorber 118 to the desired pressure, similar to pumping air into a bicycle tire, by attaching a bicycle pump or the like to the air valve 198 at the end of the accumulator body 192. The starting

pressure of the accumulator chamber 196 would typically be approximately one hundred and thirty psi for a person weighing one hundred and thirty pounds--almost a 1:1 ratio for the present bicycle design. However, different bikes and linkages require different pressure ratios since all bikes do not travel the same. A larger person would use more air in the accumulator chamber 196. That is, he would charge the accumulator air chamber 196 with additional air pressure. He would also probably tend to turn the barrel valve 156 down to restrict the flow through it since the shock absorber 118 would otherwise be too easy for him to compress.

FIG. 12 is a schematic of the hydraulic circuit of the shock absorber of FIG. 2, for example, and is represented generally by reference numeral 200. This circuit 200 includes the single-acting cushion cylinder 130 which feeds into the compression control pin 132 (which is linear position dependent), which in turn feeds into the (three-port) barrel valve 156 (where the flow rates are dependent on the rider-adjustable rotational position of the valve). As previously described, the barrel valve 156 has three ports -- a primary port 164, a high-speed compression port 162, and a low-speed compression port 160. The primary port 160 feeds directly (through an opening 182 in the shim 172) as denoted by flow line 204, to the back of the gas-charged accumulator 128 (or 192) (whose pressure curve is dependent on the starting and ending volumes and the top-out thereof is hydraulically cushioned). The flows through the high-speed and low-speed compression ports 160, 162 are through the shim valve 172 (whose maximum openings are dependent upon the shock pressure spike). The oil from the high-speed and low-speed compression ports 160, 162 passes through the cantilevered shim valve 172 and also passes through line 206 to the gas-charged accumulator 128.

FIG. 16a is a chart showing different valve data of the barrel valve 156 and the headings of each of the chart

columns are explained below. "Degree rotation of barrel valve" indicates the amount of rotation of the barrel valve 156 where zero degrees represents zero flow or "lock" and ninety degrees is fully open. "Compression time" indicates the time it would take to compress the shock absorber 118 for a given barrel valve position. "Flow rate" is the fluid flow rate at a given barrel valve 156 position and differential pressure, wherein the barrel valve positions and differential pressures are the controlling variables for these equations. The "differential pressure" is the pressure differential measured across the barrel valve 156 without the high speed slot 162. "Lohms" is the fluid flow equivalent of electrical ohms of resistance where Lohms equals $0.76/d^2$. The "equivalent diameter orifice" is the resulting orifice size at a given flow rate and differential pressure. The "orifice area" is the cross-sectional area of the equivalent diameter orifice. The "depth with 2.06 wide slots" is the resulting depth based on "orifice area" when the slot width is fixed at .06 inch.

The compression time graph of FIG. 16b and the differential pressure graph of FIG. 16c are the controlling functions that drive the data table of FIG. 16a. The resulting slot depths can be used to generate the profiles of the slots 160, 162, 164, which are then cut into the barrel valve surface 178, as best shown in FIG. 11.

The shock absorber 118 of this invention are configured so as to easily mount to nearly all-existing suspended bicycles with little modifications or special mounting elements. The shock absorber 118 is constructed with the proper interfaces at both ends thereof, such as referring to FIG. 10, a universal moving connector 210 at one end and a universal mounting flange 212 at the other. The mount on the universal mounting flange 212 can be an eyelet-type of stationary connector 216, a clevis, a strut interface or a linkage interface. (Clevises and eyelet connectors are commonly found on hydraulic cylinders.)

Referring to FIG. 1, the eyelet end 216 can be secured to an existing triangular mount 220 on the frame 102. The other end then can be secured into the connector 226 at the head end of the strut assembly (or rear fork) as shown in FIG. 18 in isolation generally at 228. This connector 226 is formed in the rear crown 229 of the strut assembly 228 and the two struts 230, 232 angle out from the rear crown to respective frame interface ends 234, 236. That is, the shock absorber 118 interfaces with the frame 102 at the stationary front triangle 220 and at the other end to the strut assembly 228. The strut ends 234, 236 then connect to the swing arm or moving part 240 of the frame with a pin (or belt) type connection. The strut assembly 228 of FIG. 18 differs from conventional struts in that it is designed to be as stiff and light as possible. The swing arm 240 is a two-force member that must be able to travel through an arc. This can be either through a pivotal connection or with a flexure construction so as to allow it to bend as it moves through the arc; that is, the deflection can be taken up in the material itself.

In other words, there must be a way to translate the linear (up-and-down) motion of the (rear) wheel 106, to the shock absorber 118. The up-and-down motion of the swing arm 240 of the rear wheel 106 is transmitted to the shock absorber 118 by a connection to the frame 102 and to the swing arm and that can be by a linkage, a strut or a direct connection to the swing arm. The connection to the frame can be a pivotal connection or a non-pivotal connection. A non-pivotal connection can be a socket which the shock absorber 118 is plugged into and then clamped on tight.

One way of connecting the shock absorber 118 is to connect it to the middle of the top tube 244 of the triangular frame 102, as shown in FIG. 17, in which case the connecting strut 246 (or 228) forks around the seat tube 248. An advantage of connecting it to the middle of the top tube 244 is that it gives the rider a better feel of the

ground, than does a connection directly below the seat 110 as shown in FIG. 1. More particularly, the FIG. 1 design does not provide as good a "feel" since the shock is almost in a one-to-one ratio with the rear wheel 106. In contrast, in the mounting to the top tube 244, it is a 3:1 ratio, meaning that when the wheel 106 moves three inches, the shock absorber 118 moves only one inch. The mount of FIG. 19 differs from that of FIG. 17 in that the arrangement of FIG. 17 requires strut 246 to interface between swing arm 240 and frame 102.

The mounting of the thumb shifter 122 on the handle bars 108 for the shock absorber 118 is best illustrated in FIG. 13. The shock control cable 124 (in its flexible sleeve) passes to the shock absorber 118 from the thumb shifter 122. Also mounted to the handle bars 108 are the brake levers 250, 252 on both of the right and left sides of the handle bars. Also illustrated in this drawing are the front wheel 104, the front brakes 252, 254, the fork crown 256, the head set 258, the handle bar neck 260, and the top tube 244 of the bicycle. Aside from the thumb shifter 122, other types of handle bar mounted controls which can be used are twist grip and finger indexed controls.

As shown in FIG. 14, for example, the control cable 124 wraps around a pulley 262. A set screw passes through a hole 264 and provides the clamping mechanism for the cable, squeezing down on the cable. A small block is dropped in first to directly grab and compress about the circumference of the cable so that the set screw is not positioned directly on the cable, to prevent the cable from being crushed by the screw. The cable is spring loaded by the return spring 268, which is positioned within the main valve housing. The cable 124 then passes up to the handle bars 108 of the bicycle where it is actuated by any number of available mechanisms 122, in a manner which would be apparent to those skilled in the art from this disclosure.

A retaining cap 270 is provided so that a seal can be made for the passageway through which the shaft of the barrel valve 156 passes.

Once the shock absorber 118 is in place on the frame 102, the stationary pivot nut with the cable housing holder and shock nut 272 can be placed on the stationary pivot bolt, as shown in FIG. 14. This holder/nut 272 acts both as a nut to hold the stationary pivot bolt in place and as a cable housing holder. The process of installing the control mechanism includes connecting the cable shifter and control to the shock pulley 262. This is done by first installing the cable shifter mechanism 122 on the handle bars 108. (This shifter mechanism 122 can be identical to shifters used in controlling rear derailleurs of multi-speed bicycles.) The cable 124 is then routed along the frame 102 to the shock cable housing holder/shock nut 272. The cable 124, once connected to the shifter 122, can be routed or installed through the housing and housing holders, wrapped around the cable pulley 262 (with the shifter 122 set to the first gear), and then tightened by the cable retaining screw 274 in the cable pulley 262.

FIG. 15 shows a shock absorber 280 having its adjustment mechanism comprising a handle 282 mounted directly thereon which the bicycle rider can easily access and controllably turn as he rides the bicycle, to thereby turn the barrel valve 156; this is instead of the handle bar mounted shifter 122. At intervals, stops limit the motion to ninety degrees, so that the barrel valve 156 is timed to the passages in the body. Although the barrel valve design can be used with up to one hundred and eighty degrees rotation or as little as fifty degrees rotation, the ninety degree choice is the preferred. A return spring (268) is not needed for the handle design of FIG. 15 because it does not need to return a cable.

A second design of the shock absorber is the single axis design wherein the axis of the transfer tube and the

accumulator chamber are aligned. Referring to FIGS. 21-25, for example, it is seen therein that shock absorber 288 includes (similar to the previously-discussed dual axis design 118) a shaft 290, a wiper 292, a primary seal 294, a bearing 296, an accumulator piston 298, a compression control pin 300, a transfer tube 302, a cantilevered shim 304, a barrel valve 306, a universal valve body 308, an eyelet-type stationary connector 310, a movable end connector 312, a retaining cap 314, a return spring 316, an opening for an air valve 318, and a pulley 319. The barrel valve 304 similarly includes a low-speed compression port 320, a high-speed compression port 322, and a primary port 324, and the flow rates are dependent upon the rotational position of the barrel valve relative to the shim 304. A top-out/transfer orifice 326 keeps the shaft in the house and provides a seal between the transfer tube 302 and the accumulator. A top-out bumper 328 and a bottom-out bumper 330 cushion the end movements of the shaft. Although the function of the shock absorber is the same for the single as the dual axis configuration, the relative arrangement of the components is different. This is explained with regard to the hydraulic circuit as shown in FIG. 26 and discussed below.

The hydraulic schematic equivalent circuit of the single-axis shock absorber of FIG. 26, for example is shown generally by reference numeral 334. Hydraulic circuit 334 includes a single-acting cushion cylinder 336 (which includes the transfer tube 302 in FIG. 22) and a compression control pin 300, which is linear position dependent and acts as a valve. This is similar to the bi-axial design illustrated in FIG. 12 and previously described. Fluid can flow in both directions through the primary port 324 of the (three port) barrel valve 304 through line 340. Flow from the compression control pin 300 is through the high-speed and low-speed ports 322, 320 of the barrel valve 306 unless passed through the cantilevered shim 304, whose maximum

opening depends on the pressure spike. The shim 304 prevents any return flow through these two ports. Flow through the shim 304 and through the high-speed and low-speed ports 322, 326 then passes through a flow line 344 to the gas-charged accumulator having piston 298. This accumulator has its pressure curve dependent on the starting and ending volumes thereof and its top-out is hydraulically cushioned by the piston/control pin 300.

A further advantage of the present invention is that the shock absorbers 118, 334 transmit stress and function essentially as structural elements when mounted on the bicycle. This is different than shock absorbers presently on the market which can only be used as two-force members to handle compression and rebound and do not have the ability to handle the side loads associated with bicycles. Bicycles typically use a strut-type rear end. In other words, they have two stays that push up on the shock assembly and are the primary stress-carrying members in the bicycle rear end. By attaching them to a flexible type of shock, the result is a very flexible rear end of the bike. For example, the wheel on one of today's bicycles using a rubber shock can be easily moved side-to-side a half inch. One of the main complaints that serious riders have with suspended bikes is that suspended bikes are too flexible.

A bicycle (100) using a shock absorber suspension system (118, 334) of this invention does not have this flex problem, as the bicycle is essentially rigid in a sideways direction. The ability of the shock to handle side loads is due to the unique design of the bearings, as illustrated in the drawings. This design allows a load equal to the maximum compressional load to be exerted on the shock absorber shaft as if it were a cantilevered beam with the bearings sized so as not to exceed the compressional strength of the bearing material on the shock absorber housing.

The shock absorbers 118, 334 of the present invention have applications in addition to bicycle rear wheel suspension systems. For example, they can be used on motorcycles or in bicycle front wheel suspension systems, where they can be fitted into forks that utilize parallelograms or linkages to achieve the front suspension. Examples of current styles that are potential retrofits are "The Pro Flex Girvin Vector," "The Lawell Leader," and "The Rebound System."

The shock absorbers 118, 334 also have industrial applications. Generally, instead of lightweight (and inexpensive) aluminum for bicycle shocks, the shock absorbers would be made of steel or similar strong metal for industrial uses. For example, referring to FIGS. 27 and 28, they can be used on conveyer systems, such as shown generally at 350 and 352. In these systems 350, 352 they are mounted with a clevis or trunnion type of mount 354 at the end of an inclined conveyer belt 356 such that as articles 358 are transported down to the end of the conveyer belt, their motion is gradually and not abruptly stopped by impacting the end of the shock absorber. The positioning of the barrel valves 156, 306 and thereby the resistance hydraulic resistance offered by the shock absorbers 118, 134 can be adjusted with any type of controller 362. This, for example, can be an electric or servo motor, a torque motor or a servo valve. Examples of other industrial or commercial uses of these shock absorbers 118, 134 are on robots where they can dampen end of travel stops, on construction equipment for dampening the swinging motion of suspended claws or grippers, and on theme park rides where they dampen or decrease accelerations of rides in start ups and stoppings to prevent jerking movements on the riders.

From the foregoing detailed description, it will be evident that there are a number of changes, adaptations and modifications of the present invention which come within the province of those skilled in the art. However, it is

intended that all such variations not departing from the spirit of the invention be considered as within the scope thereof as limited solely by the claims appended hereto.

WHAT IS CLAIMED IS:

1. A bicycle shock absorbing system, comprising:

a bicycle having a front wheel, a rear wheel and a frame connected to both said wheels;

a shock absorber device;

mounting means for mounting said shock absorber device on said bicycle operatively between one of said wheels and said frame; and

adjusting means, supported on said bicycle and operable by a rider of said bicycle while riding said bicycle, for selectively adjusting the hydraulic shock absorbing resistance of said shock absorber device among locked, unlocked and at least one intermediate resistance condition therebetween.

2. The system of claim 1 wherein said bicycle includes a handle bar and said adjusting means includes a rider-operable adjustment member mounted on said handle bar and a cable operatively interconnecting said adjustment member to said shock absorber device.

3. The system of claim 1 wherein said bicycle includes a rider seat supported by said frame, and said mounting means mounts said shock absorber device so as to dampen the transmission of up-and-down forces of said rear wheel to said frame and thereby to said rider seat.

4. The system of claim 1 wherein said adjusting means includes a rider-operable adjustment member supported by and mounted directly on said shock absorber device.

5. The system of claim 1 wherein said at least one intermediate resistance condition comprises numerous conditions on a continuum between the locked and unlocked conditions.

6. The system of claim 1 wherein said one of said wheels comprises said rear wheel.

7. The system of claim 1 wherein said shock absorber device includes a barrel valve having at least one slot or hole on an outside diameter thereof and through which hydraulic fluid can passes.

8. The system of claim 7 wherein said at least one slot or hole has an effective fluid transmission cross-sectional area which is variable by said adjusting means.

9. The system of claim 8 wherein said shock absorber device includes valve means for providing a fluid opening system communicatable with said at least one slot or hole wherein said fluid opening system has an opening size dependent upon compression pressure and said fluid opening system is blocked upon return stroke pressure.

10. The system of claim 8 wherein said barrel valve is rotatable relative to a channel assembly having at least one flow opening so as to selectively vary the effective cross-sectional flow area between said at least one slot or hole and said at least one flow opening.

11. The system of claim 10 wherein said shock absorber device includes a reed valve and said at least one flow opening passes through said reed valve.

12. The system of claim 7 wherein said shock absorber device includes a compression-stroke fluid pathway substantially through said at least one slot or hole and a return-stroke fluid pathway substantially through said at least least one slot or hole.

13. The system of claim 1 wherein said shock absorber device includes a cylinder having variable orifice means wrapped around it and said adjusting means rotates said cylinder and thereby said variable orifice means relative to fluid passageway means.

14. The system of claim 13 wherein said variable orifice means includes first and second spaced orifices, said shock absorber device includes hydraulic fluid compression stroke and return stroke pathways, said compression stroke pathway passes through both said first and second orifices, and said return stroke pathway passes through said second but not said first orifice.

15. The system of claim 13 wherein said variable orifice means includes first, second and third generally spaced orifices, said first and third but not said second orifices flow hydraulic fluid during low speed compression of said shock absorber device, and during high speed compression of said shock absorber device said first, second and third orifices all flow hydraulic fluid with said second orifice flowing more than said first and third orifices.

16. The system of claim 15 wherein said shock absorber devide includes return stroke fluid passing through said third orifice but not said first and second orifices.

17. The system of claim 1 wherein said frame includes a substantially vertical seat tube member and said mounting means mounts said shock absorber device operatively between said seat tube member and said rear wheel.

18. The system of claim 1 wherein said frame includes a substantially horizontal top tube and said mounting means mounts said shock absorber device operatively between said top tube and said rear wheel.

19. The system of claim 1 wherein said shock absorber device includes an air spring against which the hydraulic shock absorbing resistance acts in a compression condition.

20. A bicycle shock absorber assembly, comprising:

a shock absorber assembly housing having a first end operatively connectable to a bicycle wheel and a second end operatively connectable to a bicycle frame;

a biased dampener assembly;

a piston assembly supported by said housing and having a hydraulic fluid chamber; and

a fluid channel system having an effective cross-sectional area through which fluid passes from said fluid chamber operatively to said biased dampener assembly when said piston assembly is compressed by the upward movement of the wheel relative to the frame to dampen the transmission of the resulting shock to the frame;

wherein said fluid channel system has the effective cross-sectional area being operatively changeable by the rider of the bicycle while riding the bicycle among at least three different conditions to thereby selectively vary the hydraulic resistance.

21. The assembly of claim 20 wherein said fluid channel system includes a barrel valve having fluid slot means whose effective area is variable dependent upon the rotational orientation of said barrel valve.

22. The assembly of claim 20 wherein said piston assembly includes a cylinder tube and a smooth-tipped piston slidable in said tube.

23. The assembly of claim 20 wherein said biased dampener assembly comprises a pneumatic accumulator having an accumulator piston against which hydraulic fluid from said fluid chamber acts, an accumulator chamber, and valve means for adjusting the air pressure in said accumulator chamber.

24. The assembly of claim 20 wherein said fluid channel system includes a barrel valve having fluid slot means, a compression-stroke fluid pathway through said fluid slot means in one direction and a return-stroke fluid pathway through said fluid slot means in a direction opposite to said one direction.

25. A method of adjusting the shock absorbing capability of a bicycle, comprising the steps of:

providing a bicycle having a frame, the bicycle also having a front wheel, a rear wheel, a seat and handlebars, each connected to the frame;

providing a shock absorber having first and second ends and which defines a component separate from the frame;

operatively connecting the first end relative to the frame and the second end relative to one of the bicycle wheels such that the shock absorber, when actuated, absorbs shock from the up-and-down movement of that wheel from being transmitted to the frame; and

after said connecting step and with a rider riding the bicycle, adjusting the hydraulic resistance of the shock absorber.

26. The method of claim 25 wherein said adjusting step includes locking the shock absorber in an off condition.

27. The method of claim 25 wherein said adjusting step includes turning the shock absorber to an operative on condition.

28. The method of claim 25 wherein the shock absorber has an off condition and a plurality of on conditions each providing a different hydraulic resistance, and said adjusting step includes switching between the different on conditions.

29. The method of claim 25 wherein the shock absorber includes a barrel valve having fluid slot means, and said adjusting step includes rotating the barrel valve to reposition the fluid slot means.

30. The method of claim 29 wherein the fluid slot means has an effective fluid-flow opening which is varied by said rotating step.

31. The method of claim 25 wherein said adjusting step includes the rider turning an actuator member operatively connected to the shock absorber.

32. The method of claim 31 wherein the actuator member is mounted directly on the shock absorber.

33. The method of claim 32 wherein the actuator member is mounted on the handlebars.

34. The method of claim 25 wherein the shock absorber includes a gas-pressure biased shock dampener, and further comprising the step of adjusting the gas-pressure preloading of the dampener.

35. The method of claim 25 wherein the shock absorber includes a hydraulic resistance adjustment mechanism and the bicycle includes handle bars; further comprising before said adjusting step, installing a cable shifter mechanism on the handle bars and operatively connecting via a cable the cable shifter mechanism to the resistance adjustment mechanism; and wherein said adjusting step includes operating the cable.

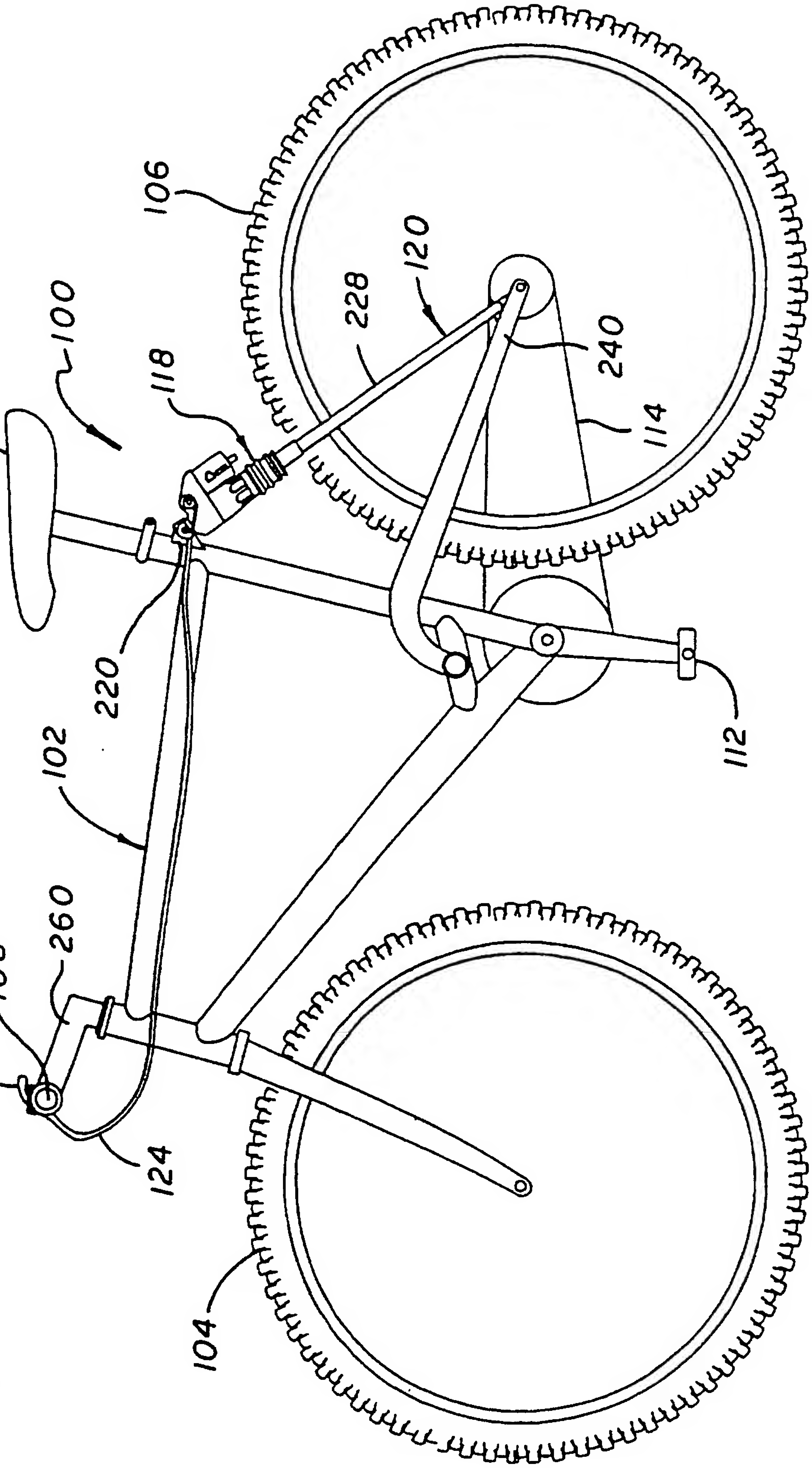

FIG. 1

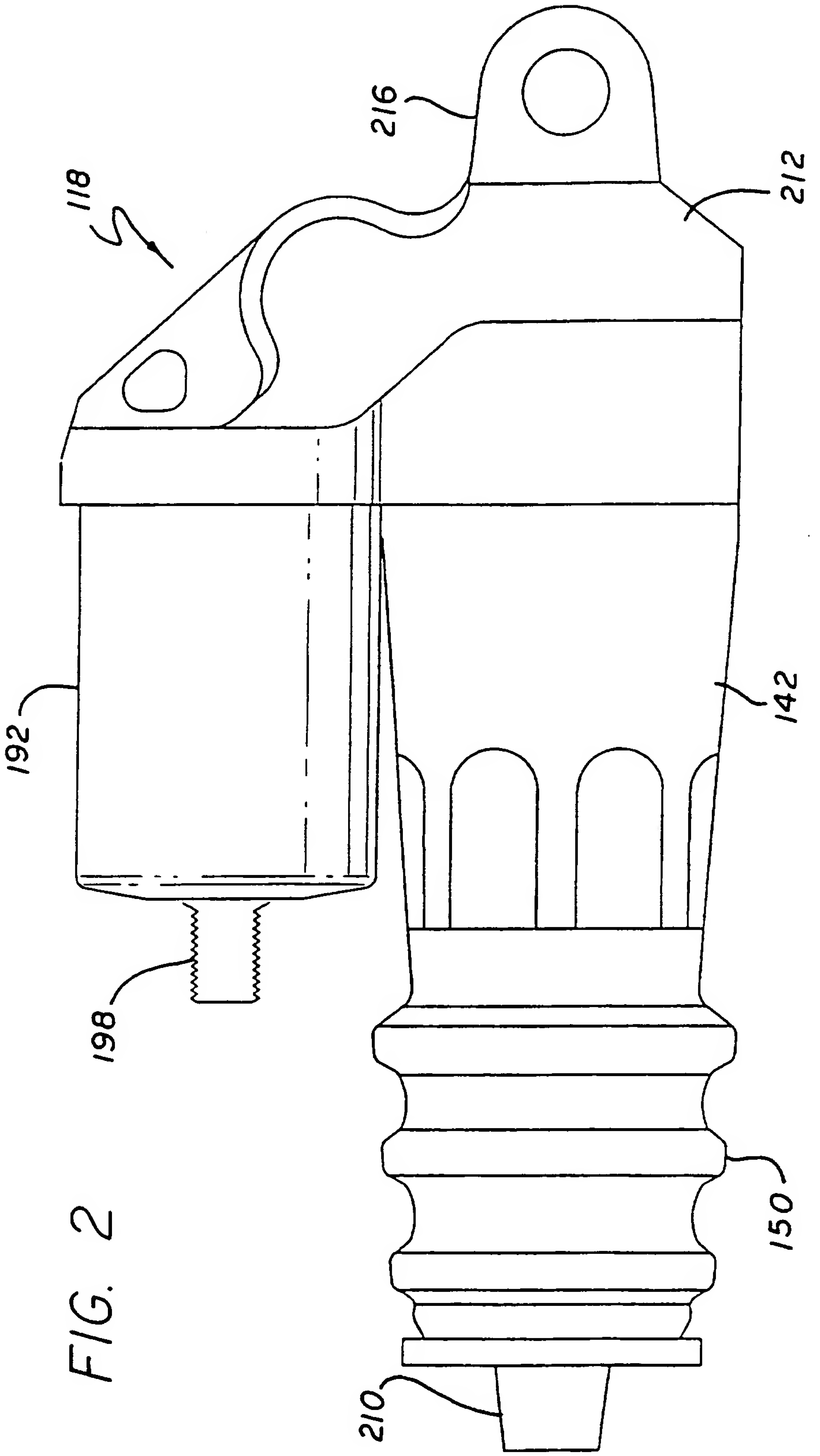

FIG. 2

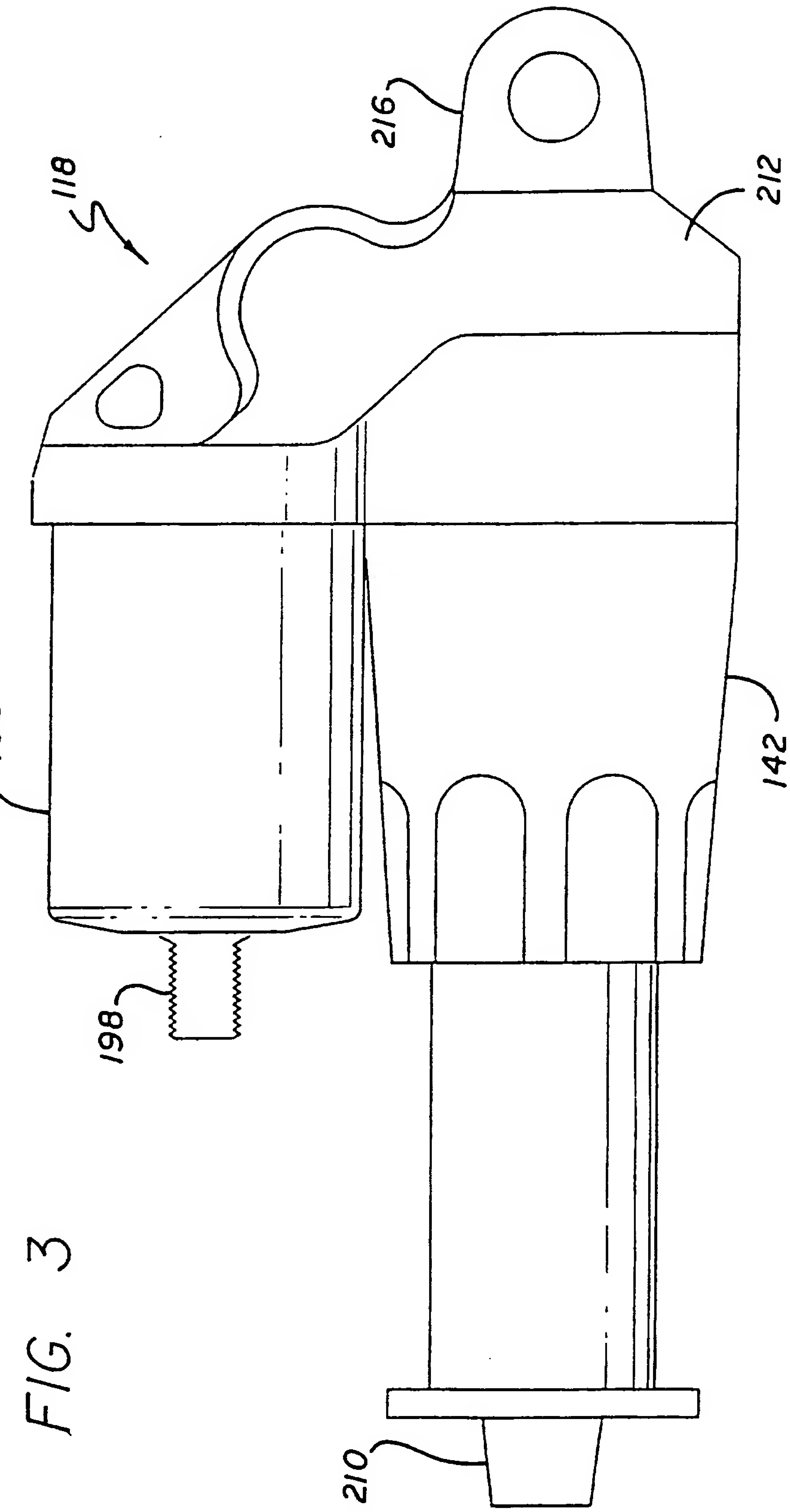

FIG. 3

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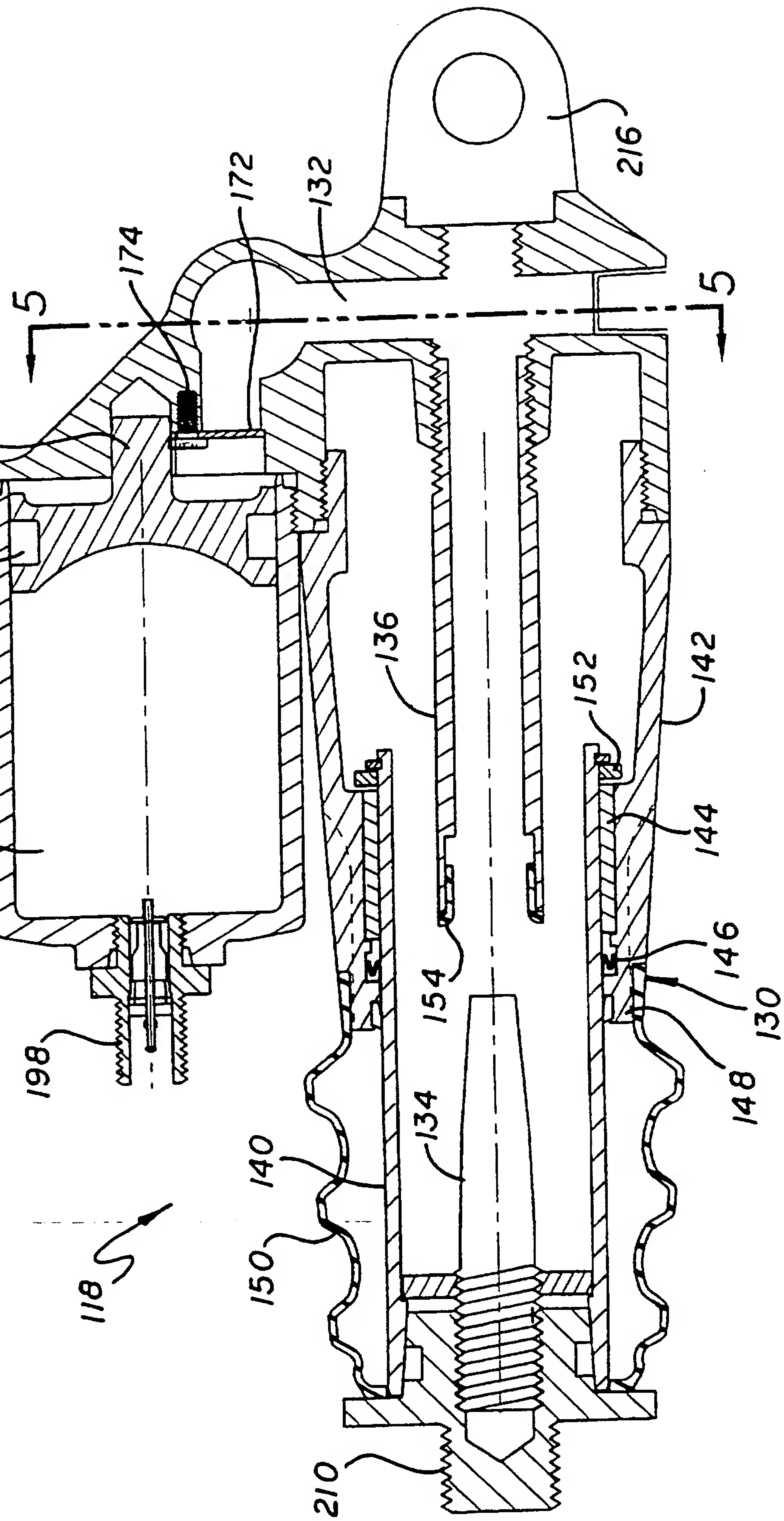
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FIG. 4

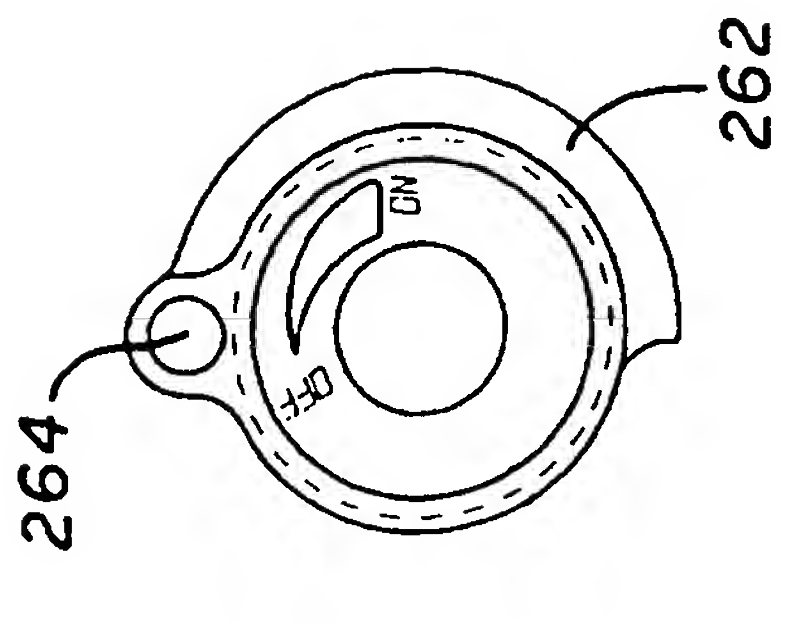


FIG. 6

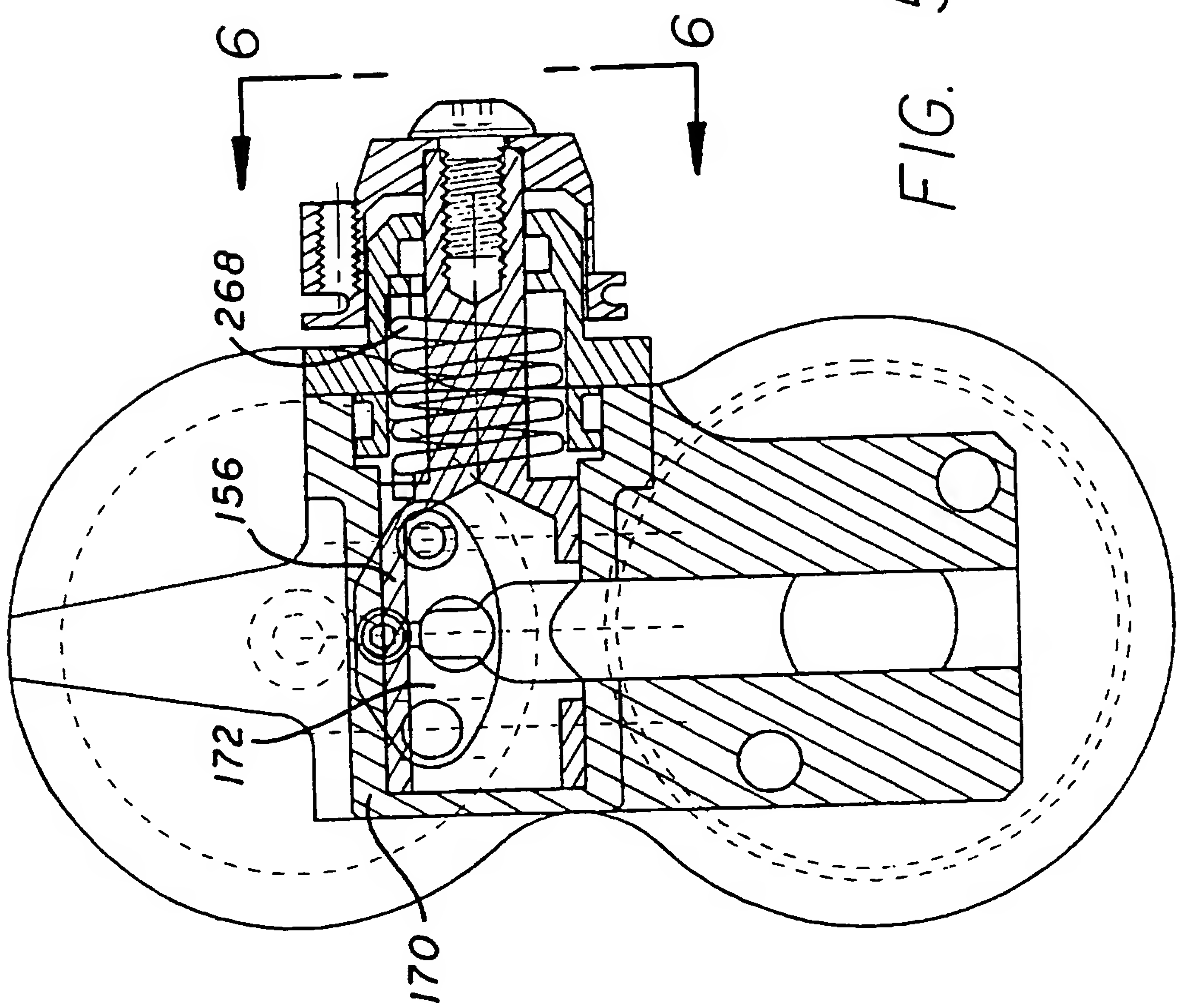
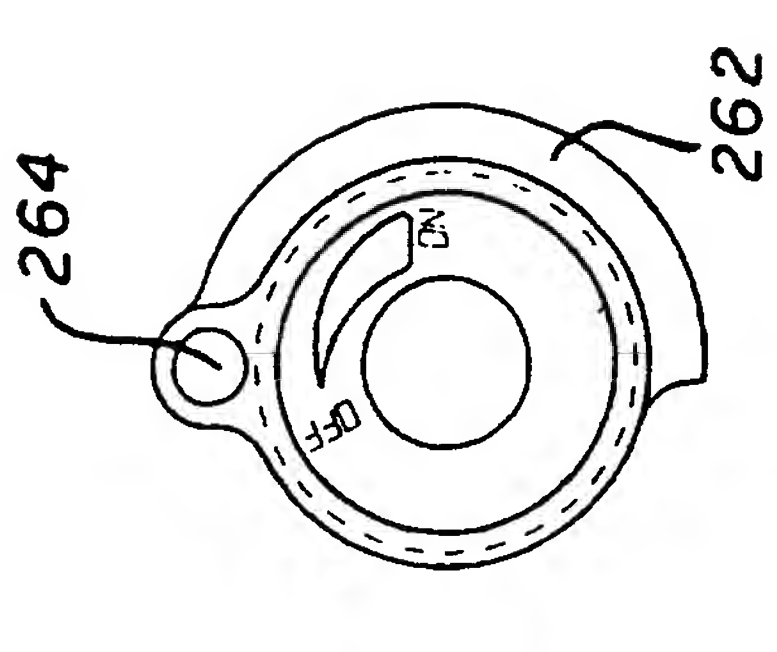


FIG. 5

FIG. 9



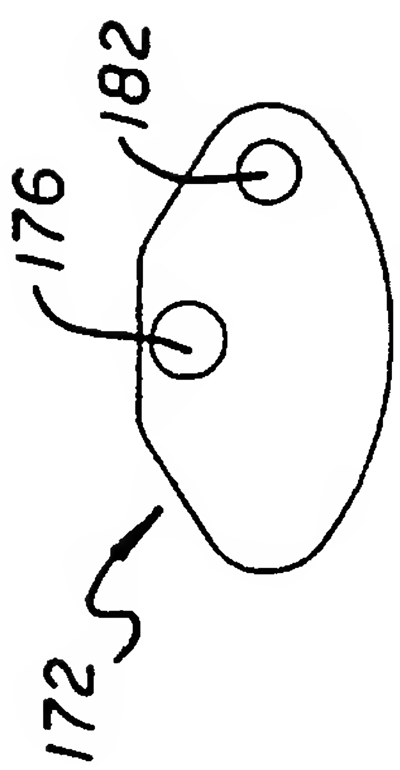
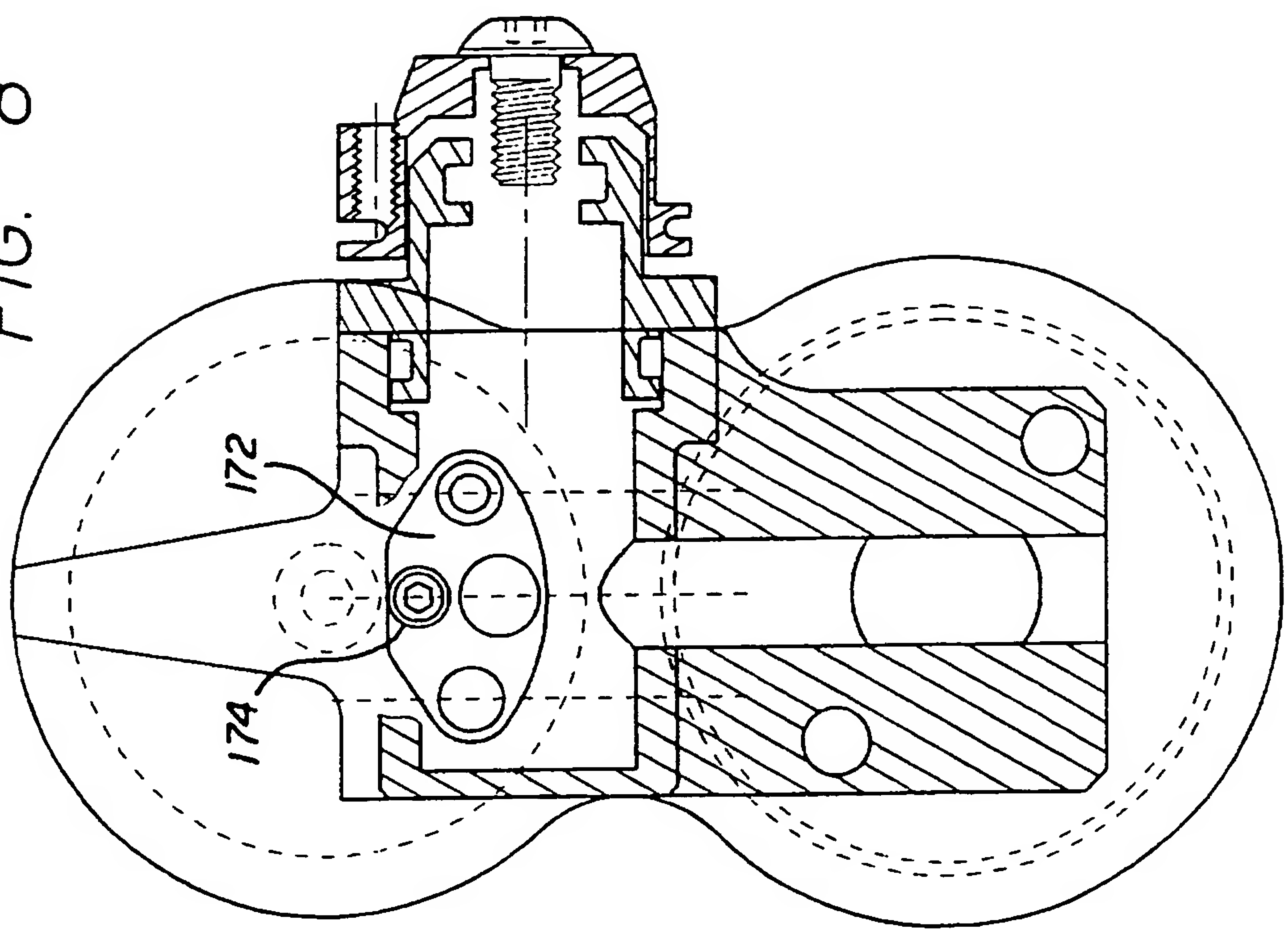


FIG. 7

FIG. 8



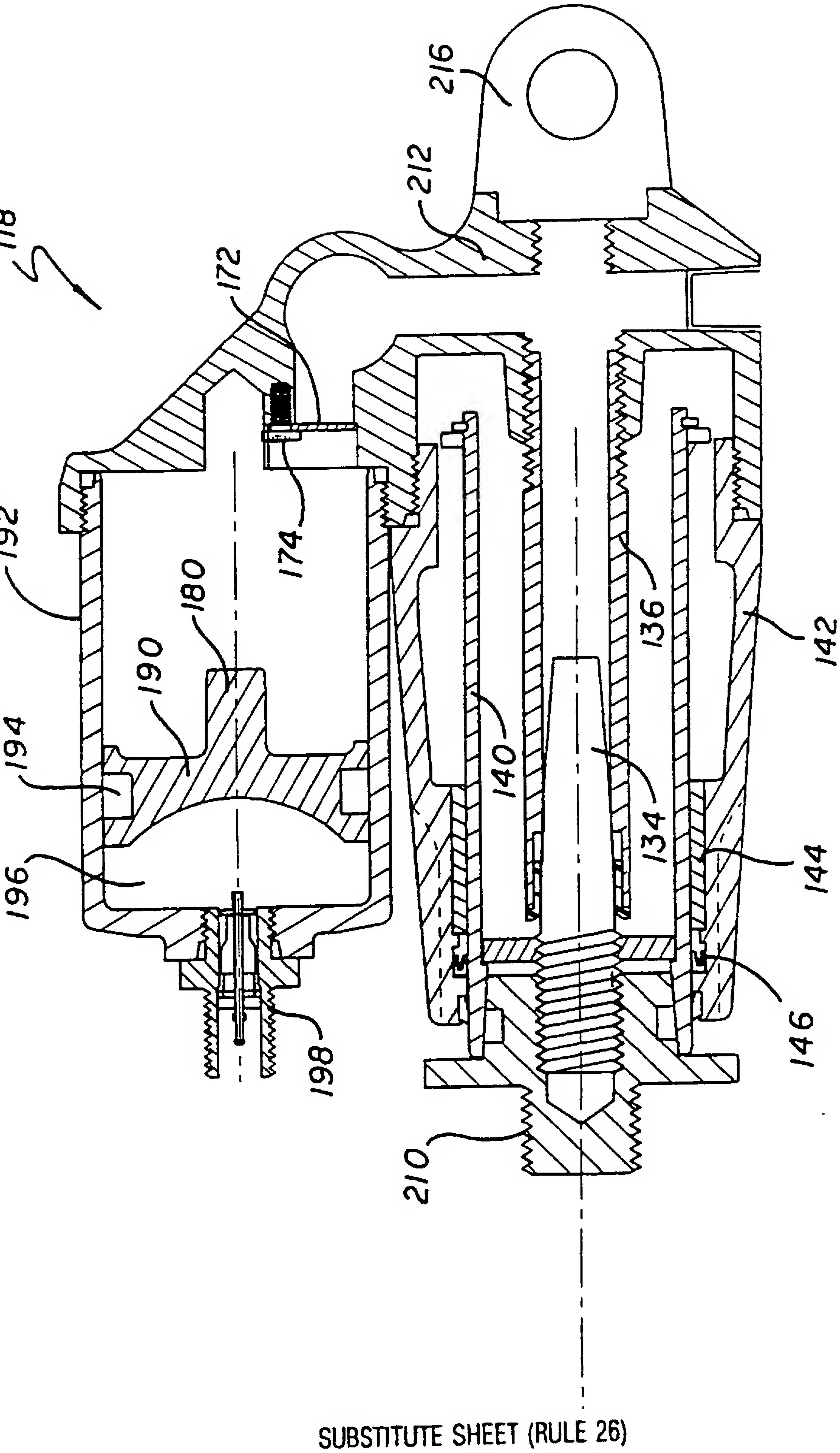

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FIG. 10

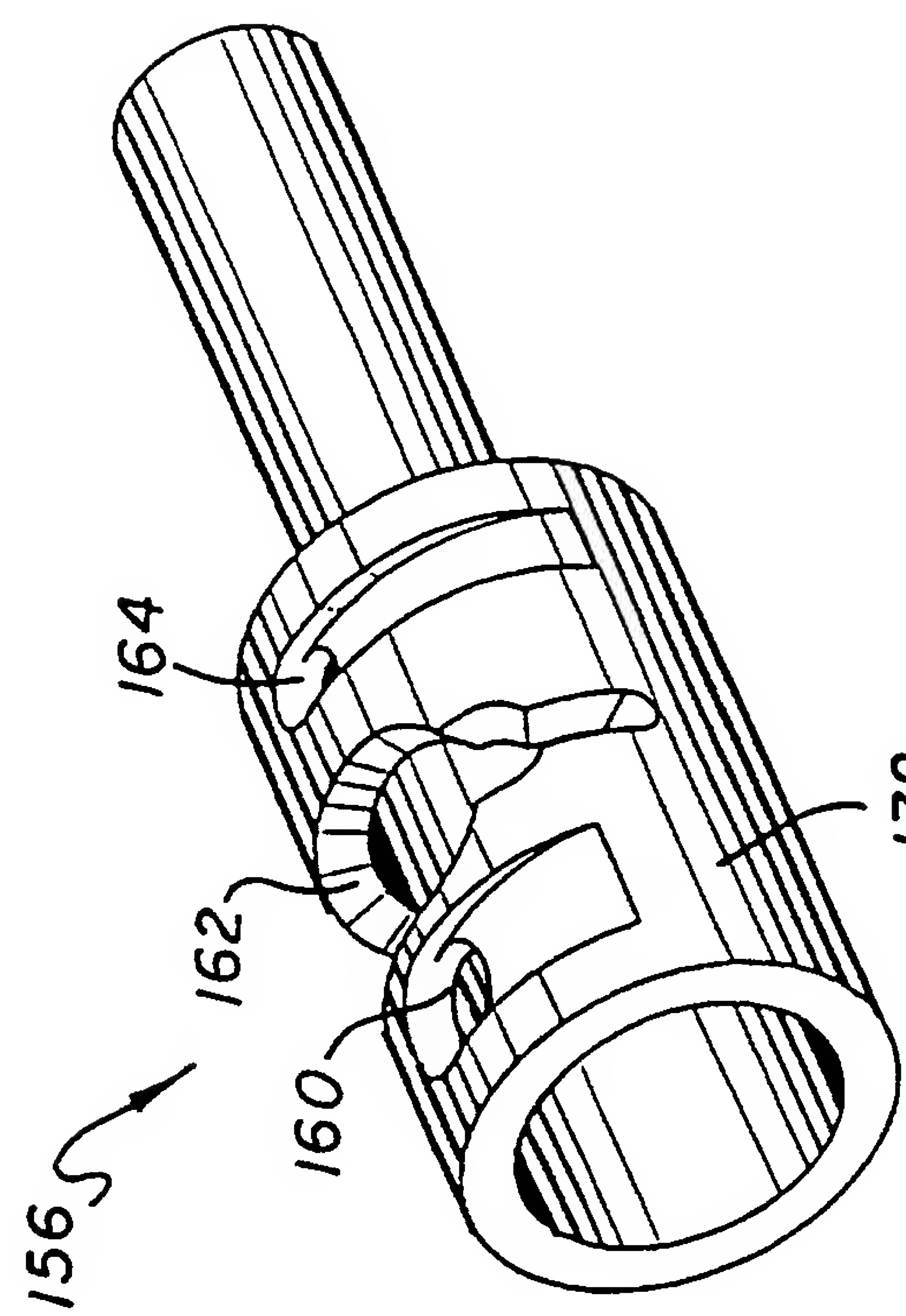
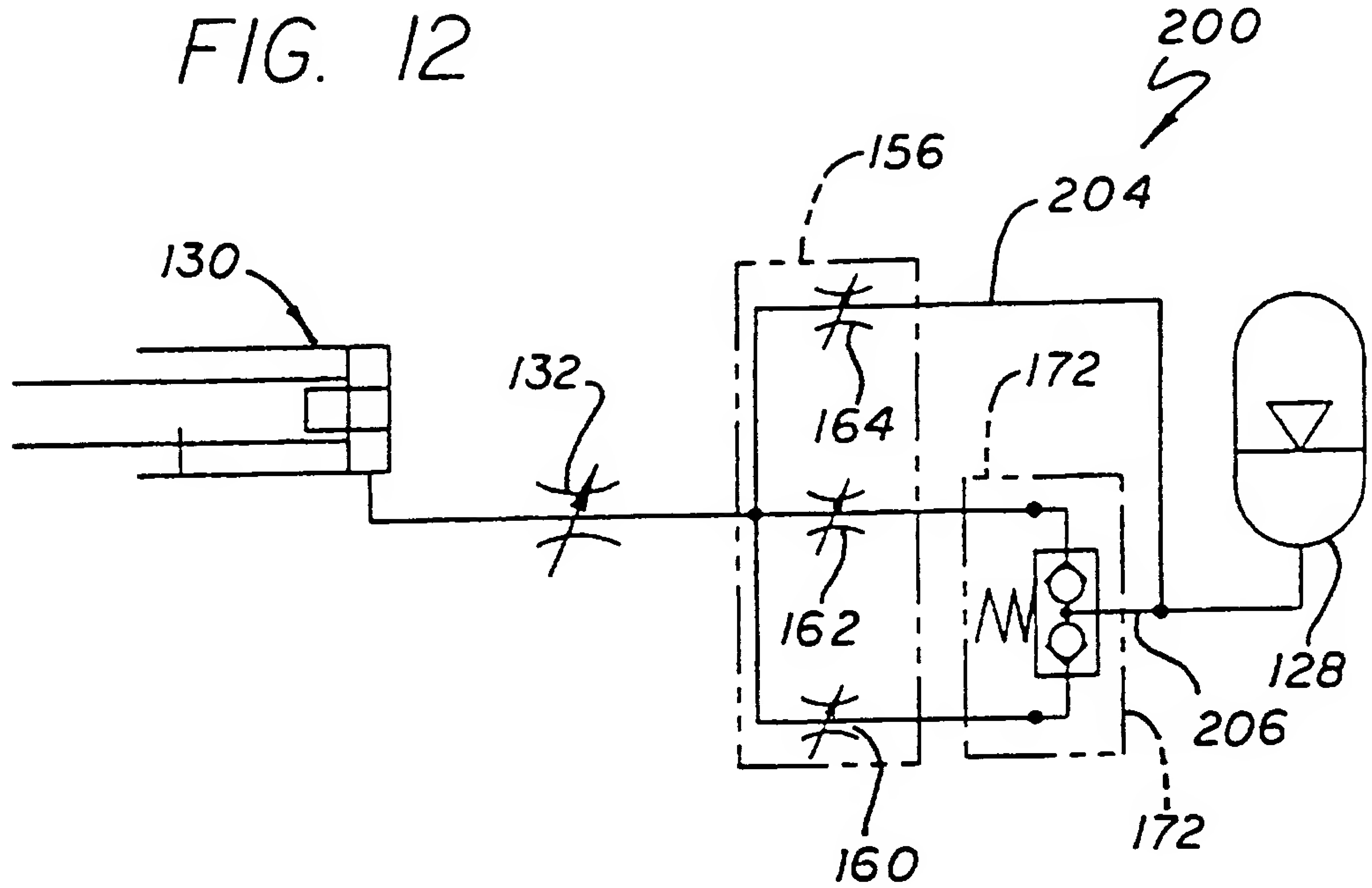


FIG. 11

FIG. 12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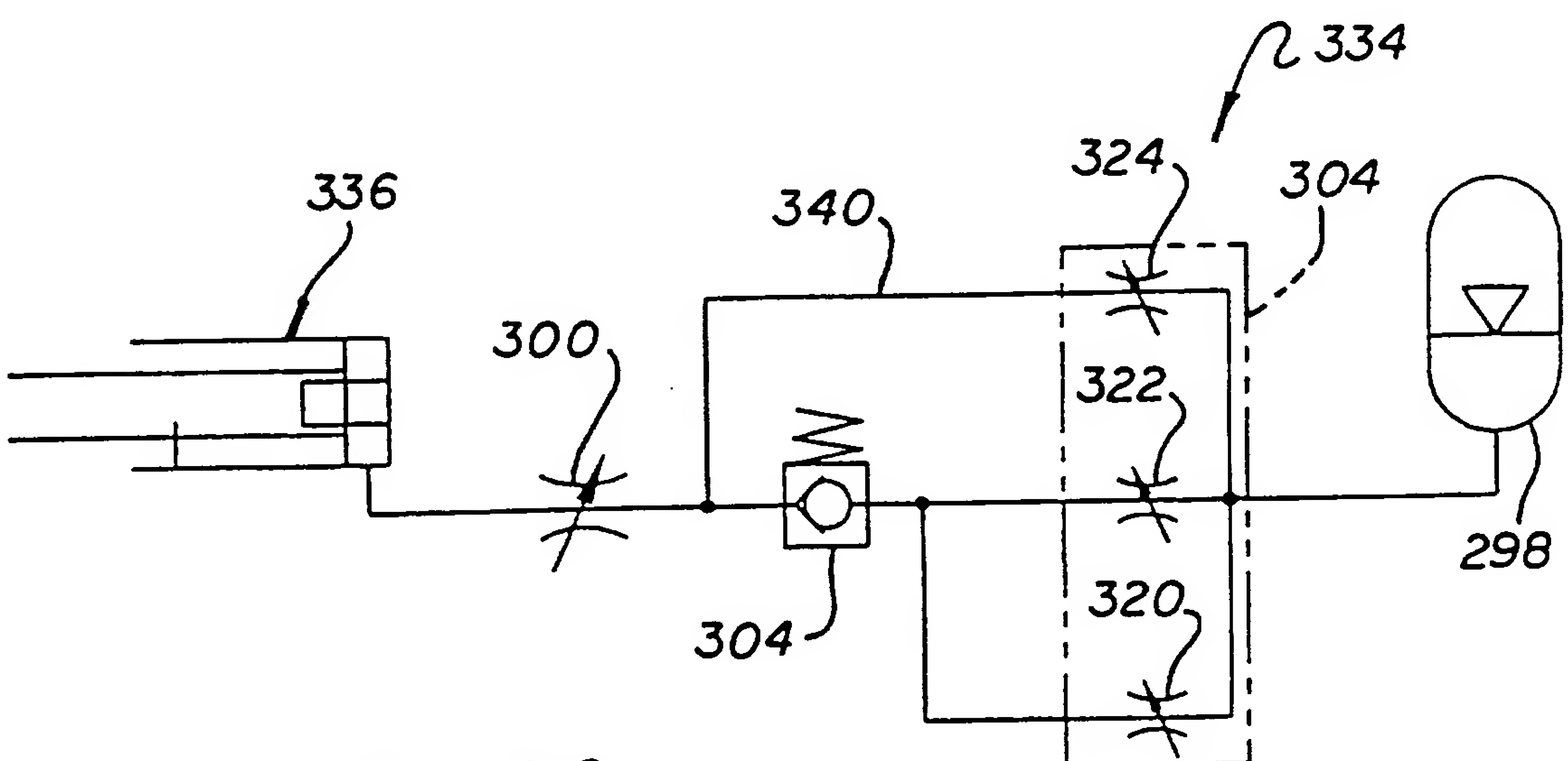
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FIG. 26

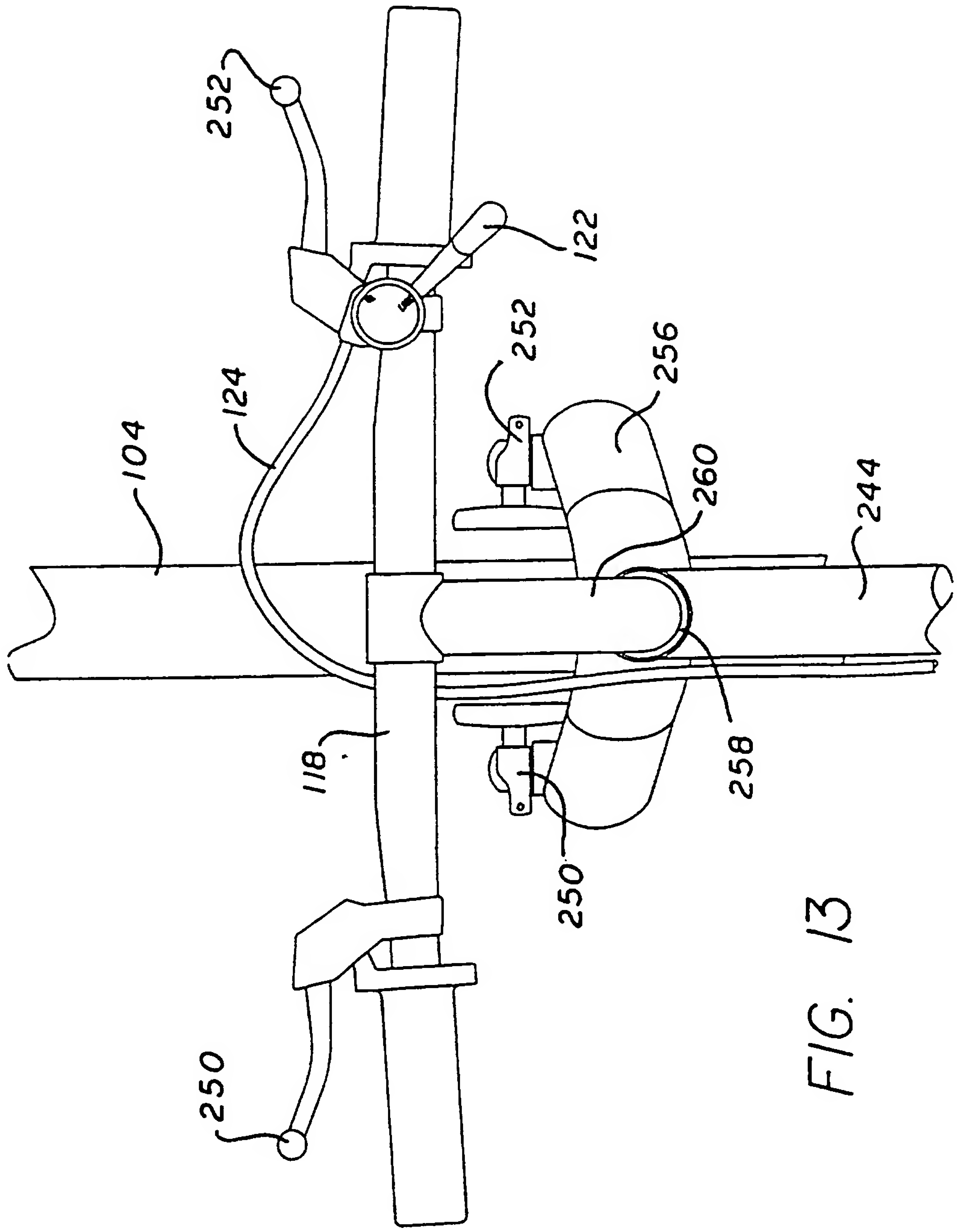

FIG. 13

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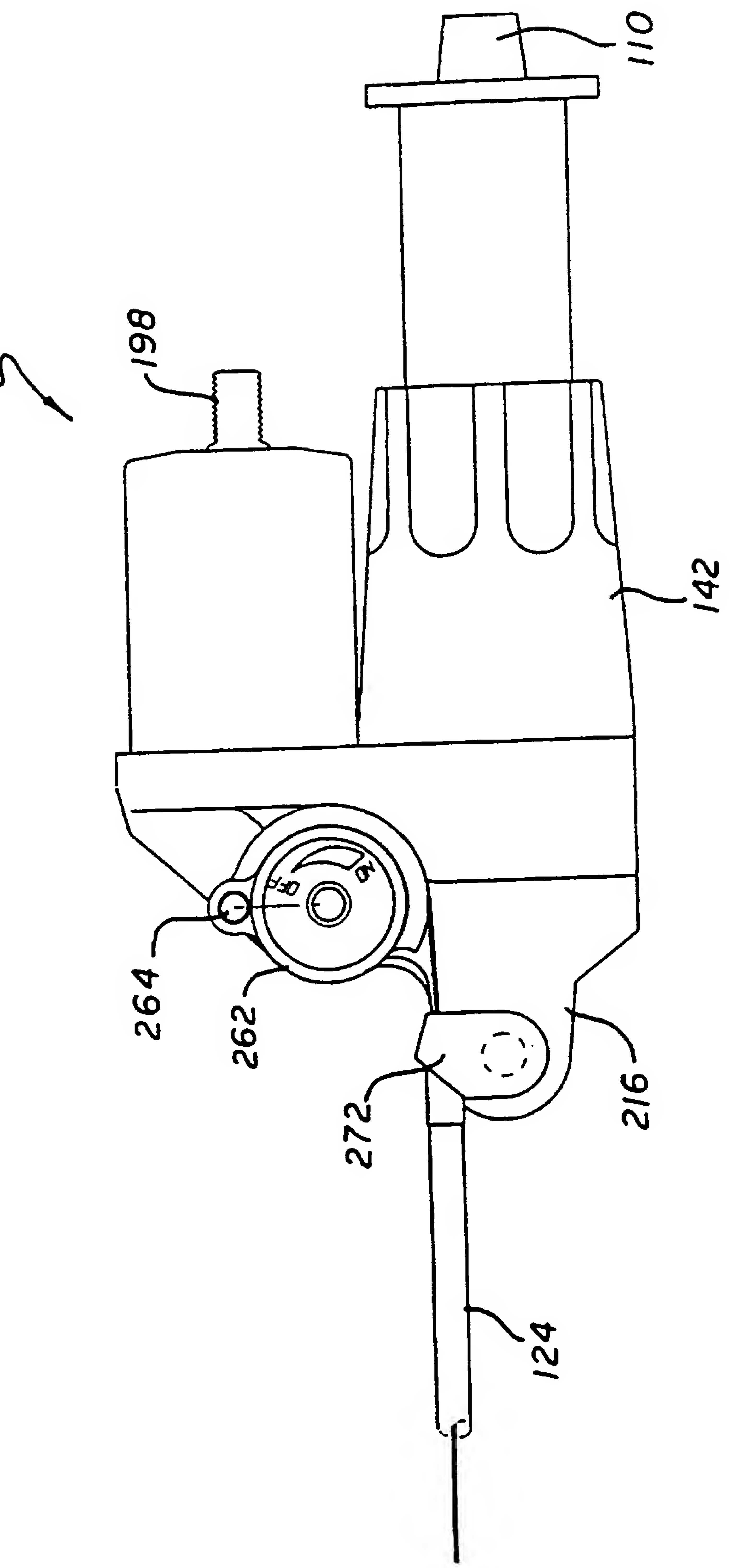


FIG. 14

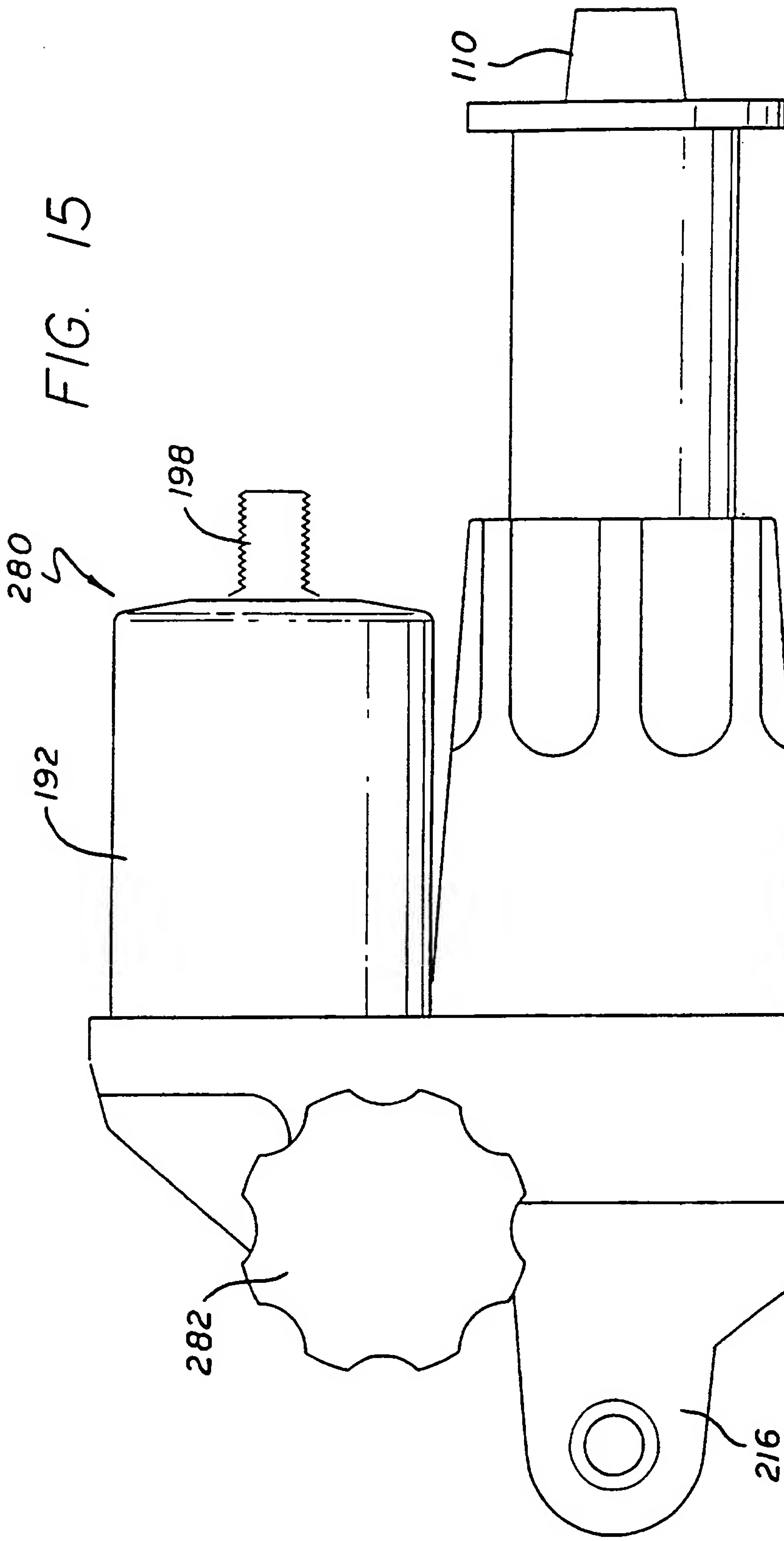


FIG. 15

FIG. 16a

BARREL VALVE DATA

DEG. ROTATION BARREL VALVE	COMPRESSION TIME (SEC)	FLOW RATE GPM	DIFFERENTIAL PSI	LOHMS	EQUIVALENT DIA ORIFICE	ORIFICE AREA IN~3	DEPTH WITH 2 .06 WIDE SLOTS
0	1.500	0.001	90	189525.72	0.002	0.0000	0.000
5	1.500	0.087	89	2184.14	0.019	0.0003	0.002
10	1.400	0.093	87	2010.98	0.019	0.0003	0.002
15	1.250	0.104	81	1733.57	0.021	0.0003	0.003
20	1.133	0.115	73	1489.75	0.023	0.0004	0.003
25	1.020	0.127	66	1276.12	0.024	0.0005	0.004
30	0.937	0.139	62	1133.45	0.026	0.0005	0.004
35	0.887	0.146	58	1042.99	0.027	0.0006	0.005
40	0.840	0.155	55	960.23	0.028	0.0006	0.005
45	0.793	0.164	53	886.54	0.029	0.0007	0.006
50	0.753	0.172	51	826.51	0.030	0.0007	0.006
55	0.703	0.185	49	758.61	0.032	0.0008	0.007
60	0.660	0.197	48	705.65	0.033	0.0008	0.007
65	0.613	0.212	48	651.31	0.034	0.0009	0.008
70	0.577	0.225	46	604.63	0.035	0.0010	0.008
75	0.531	0.245	44	539.34	0.038	0.0011	0.009
80	0.500	0.260	39	483.32	0.040	0.0012	0.010
85	0.469	0.277	30	392.95	0.044	0.0015	0.013
90	0.200	0.649	5	68.87	0.105	0.0087	0.072

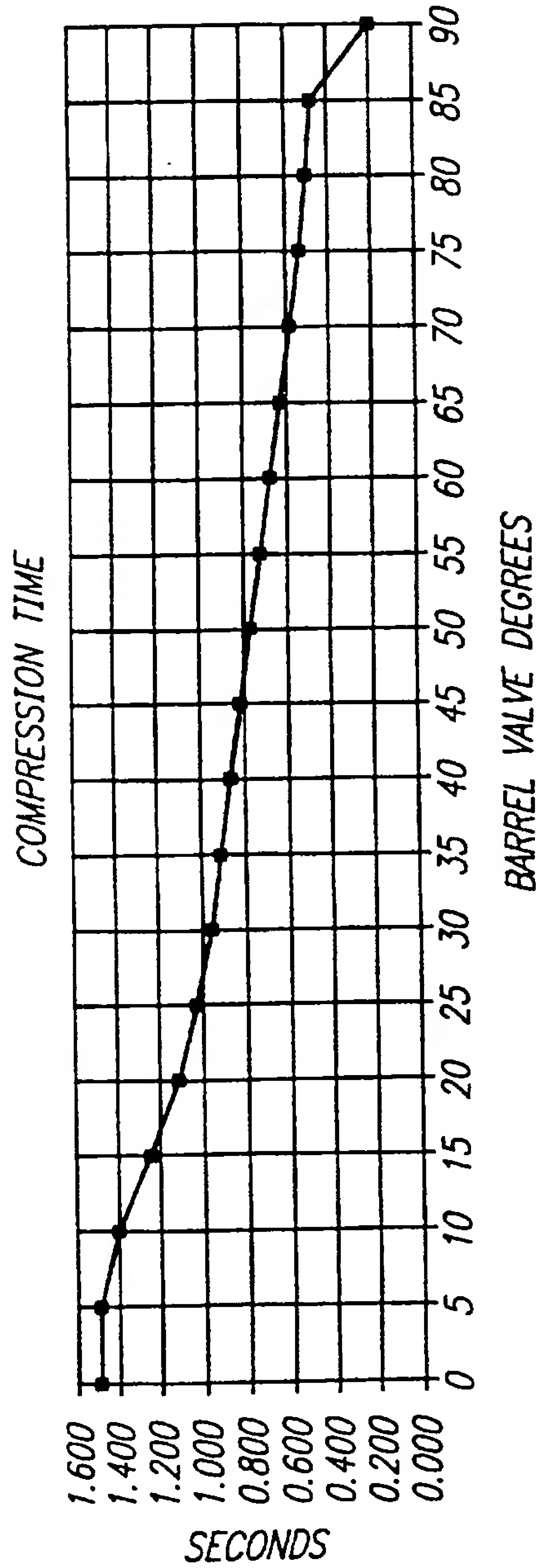


FIG. 16b

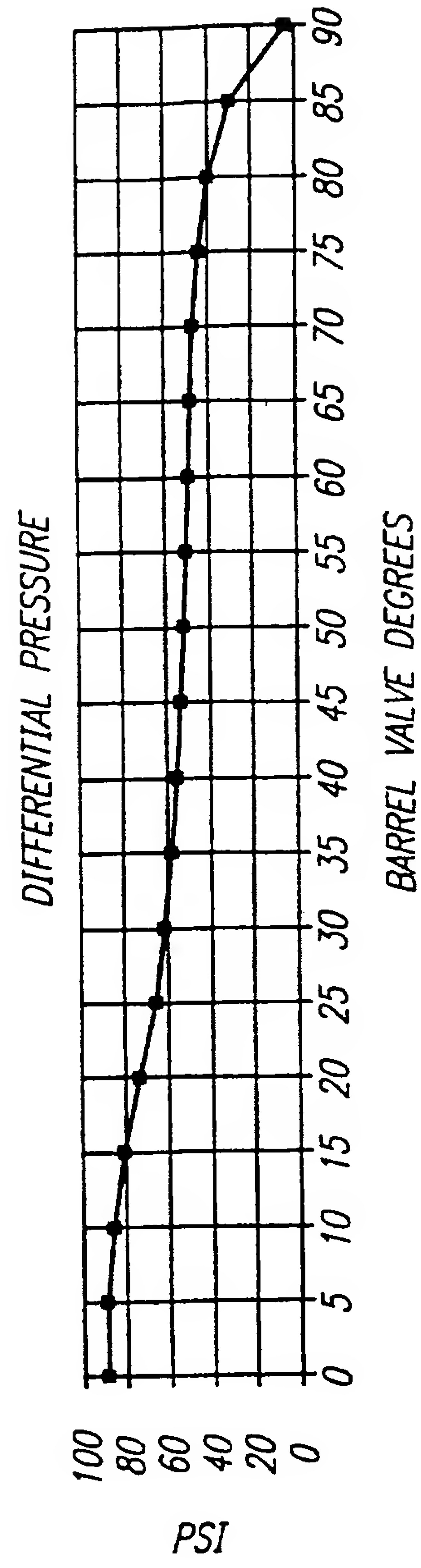
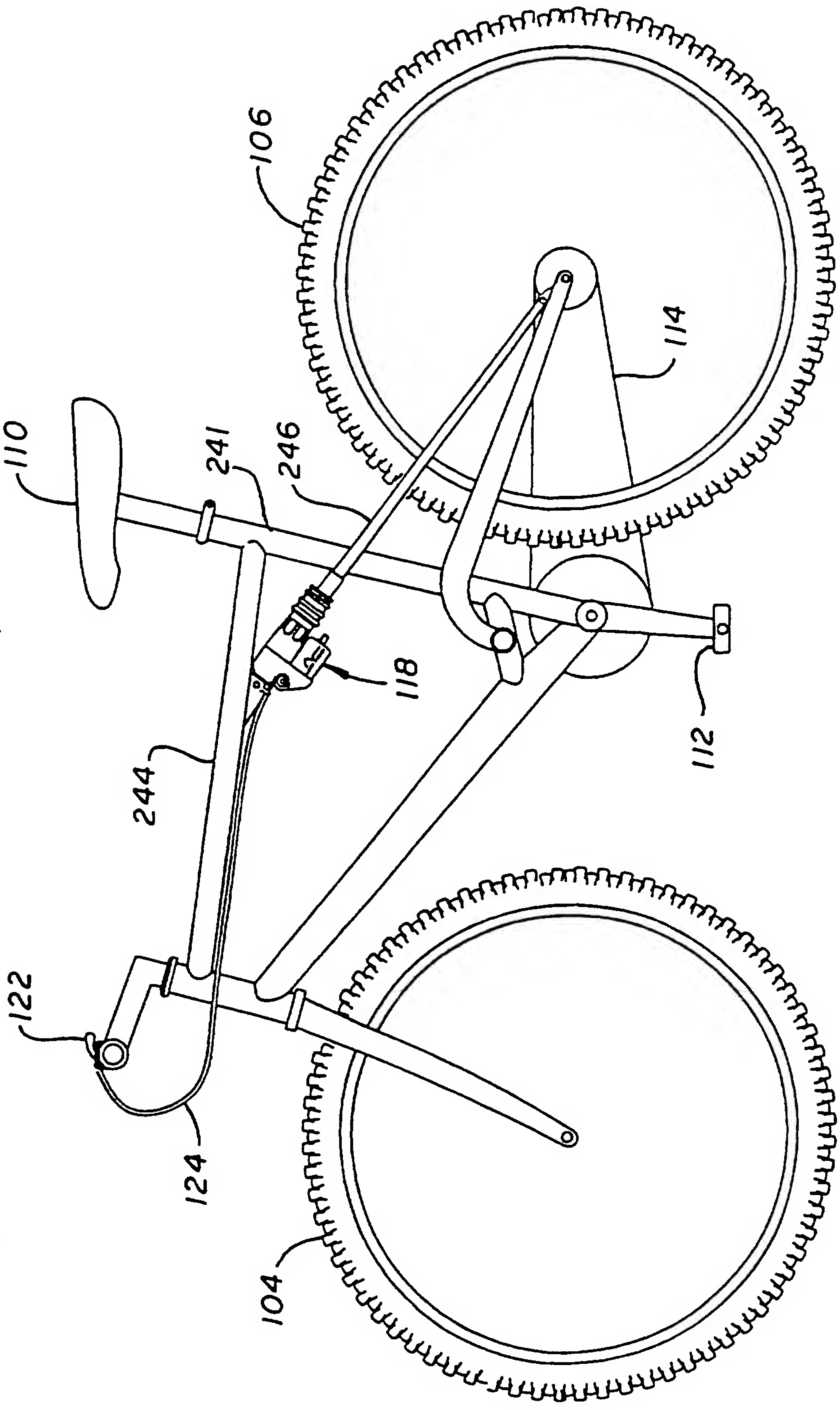


FIG. 16c

FIG. 17



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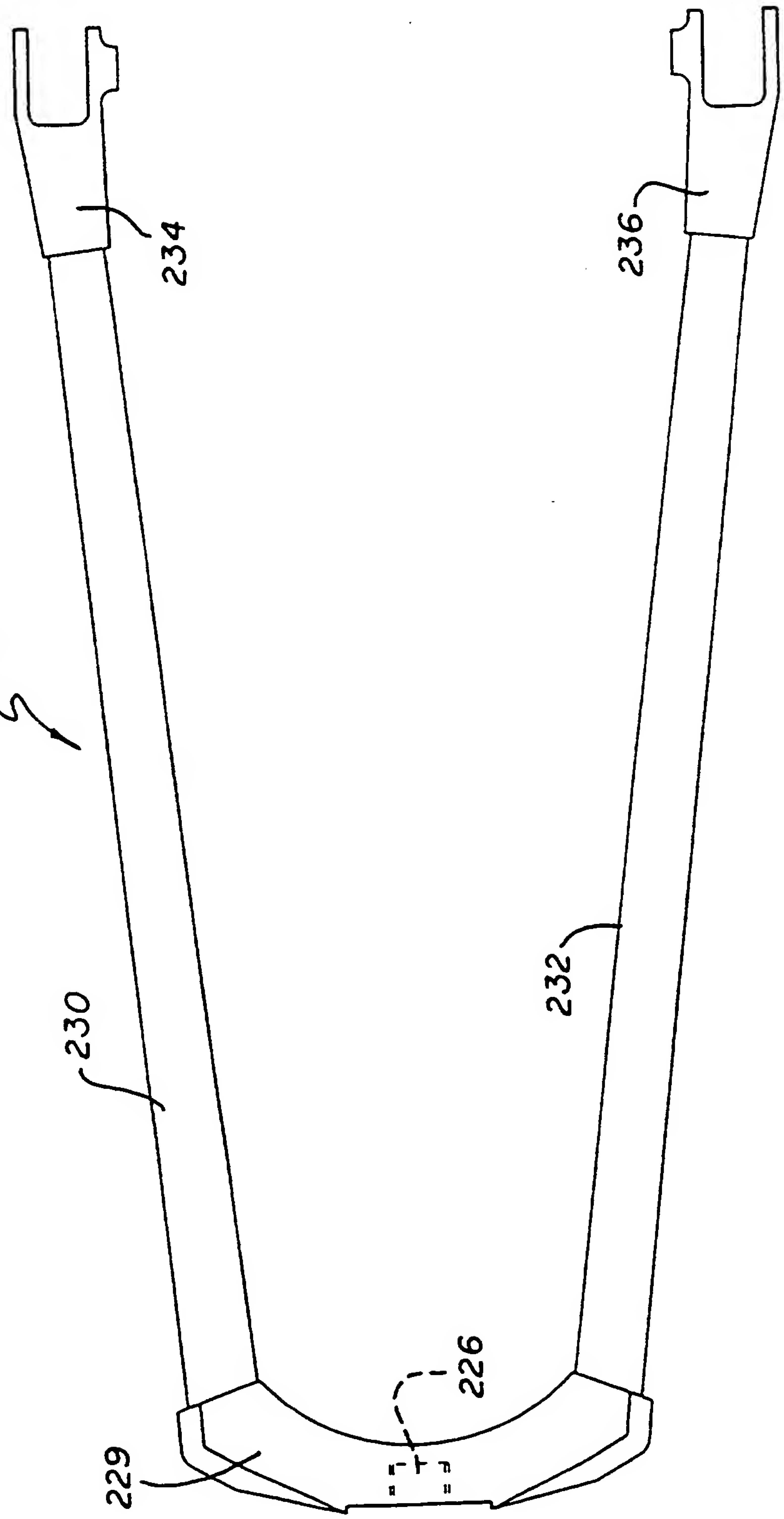

FIG. 18

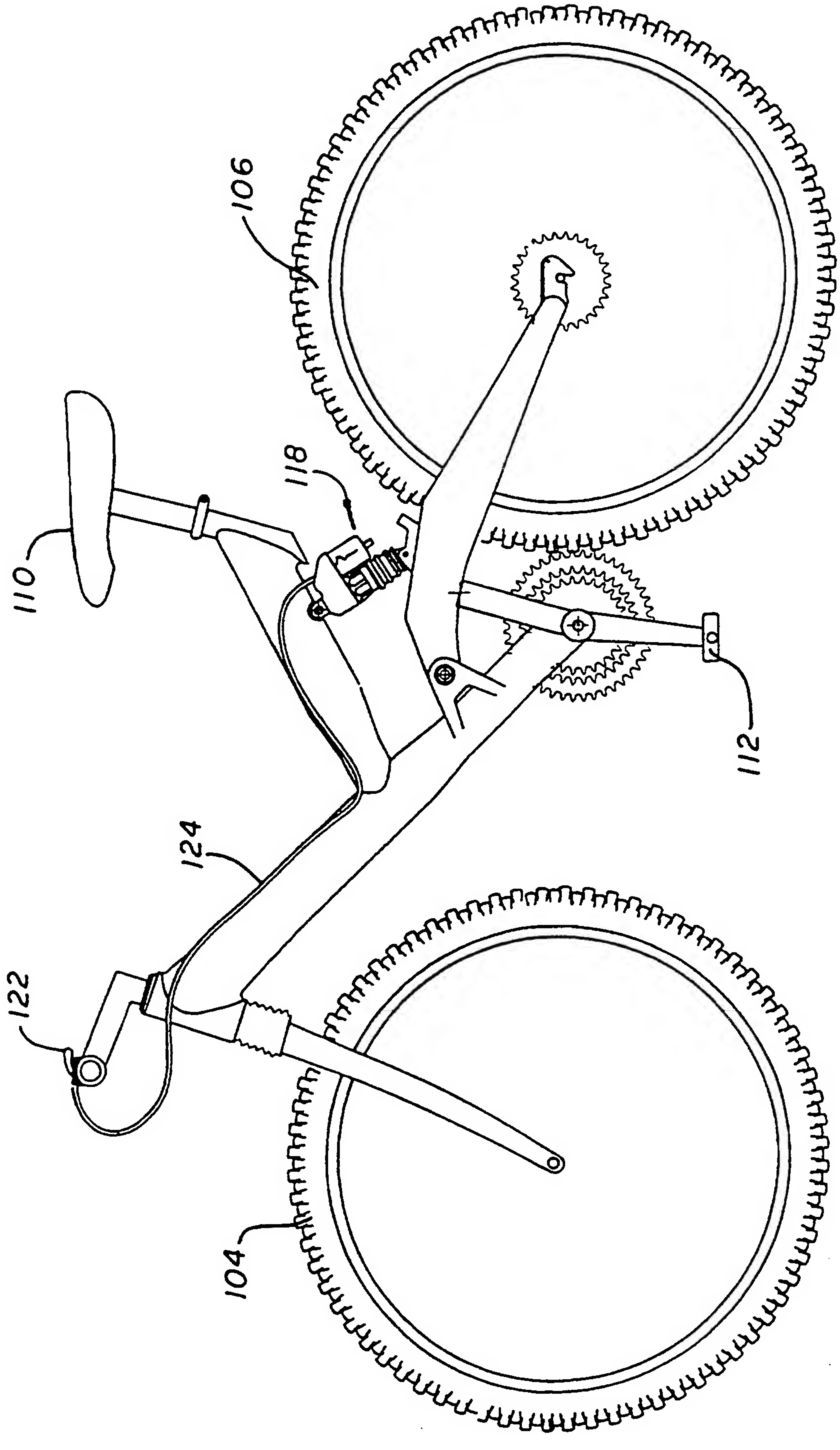

FIG. 19

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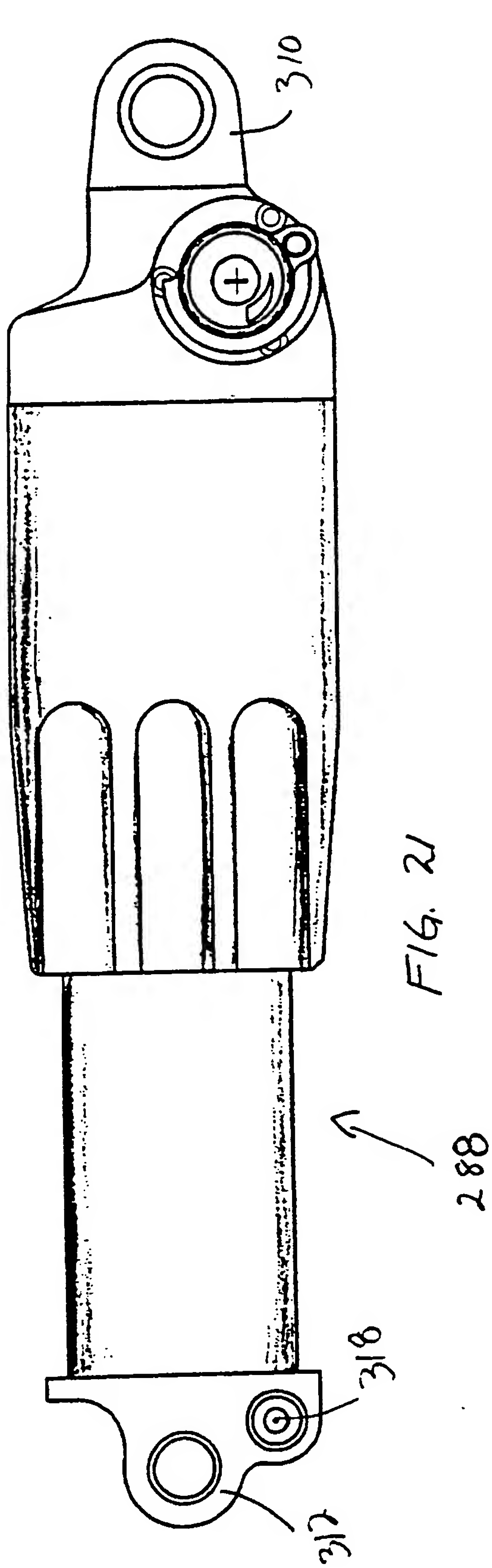

FIG. 21

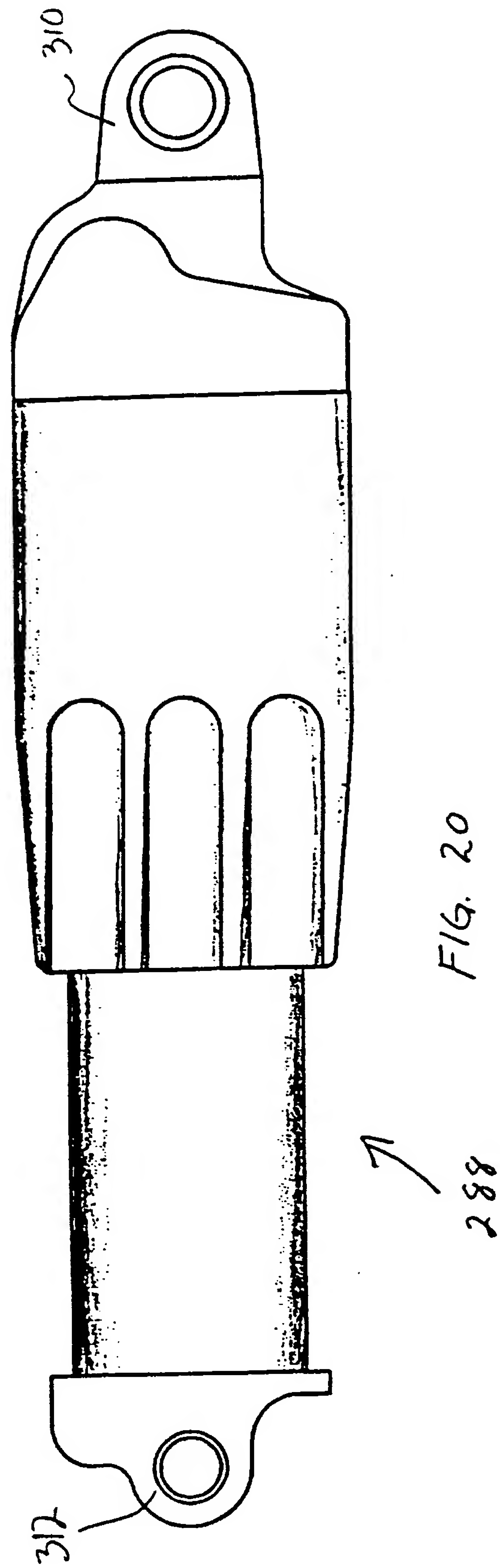

FIG. 20

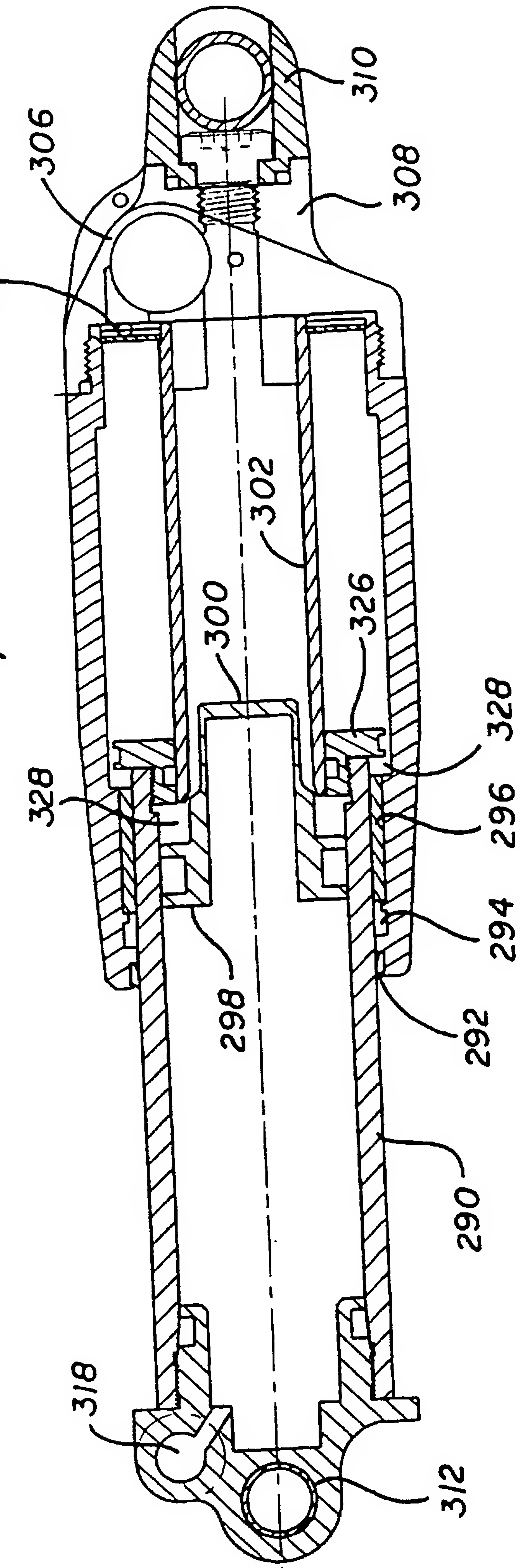
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FIG. 22

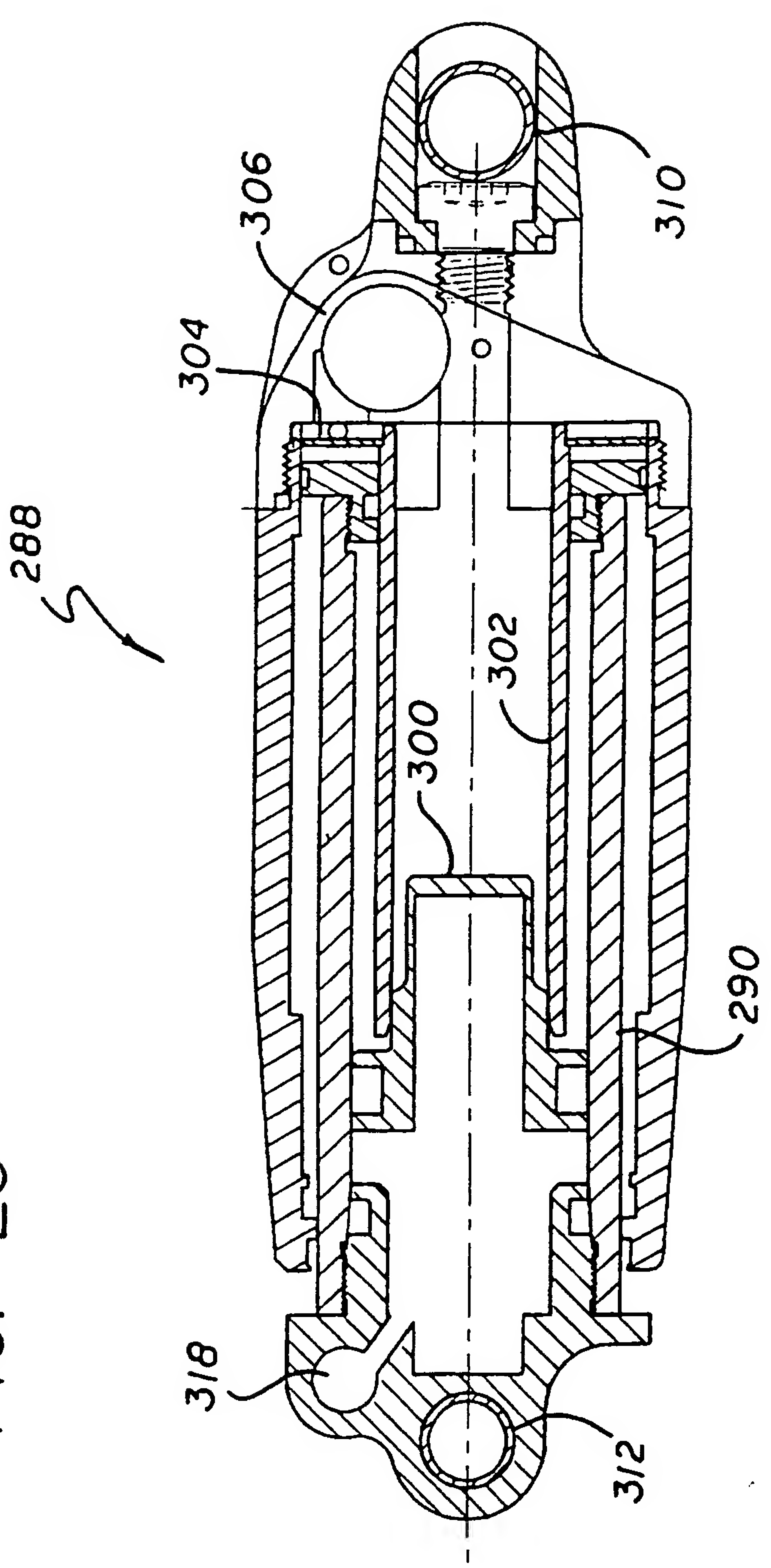

FIG. 23

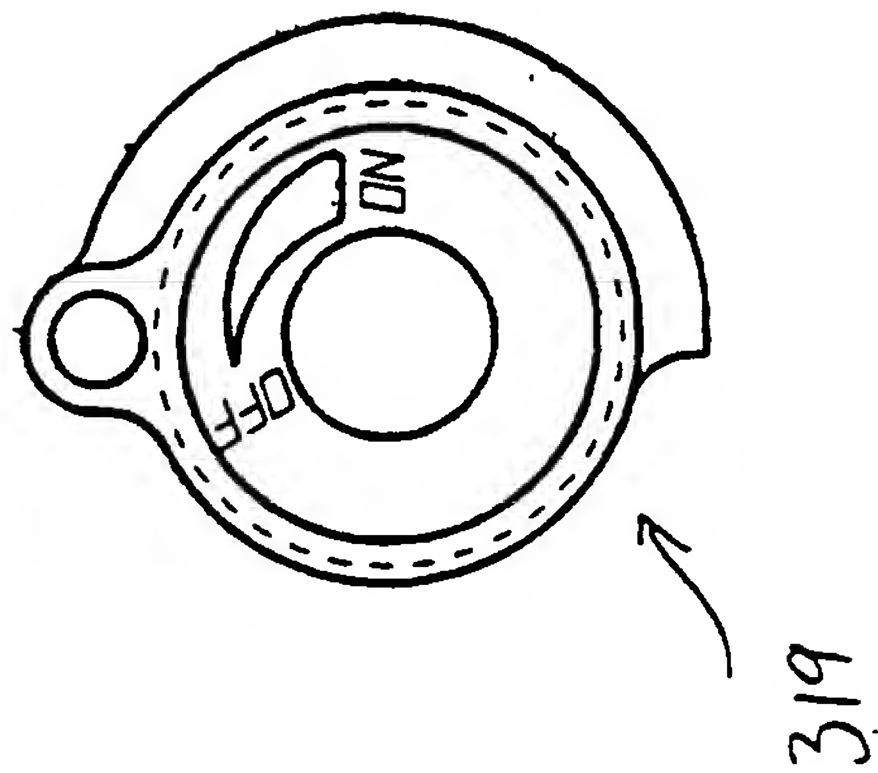

FIG. 25

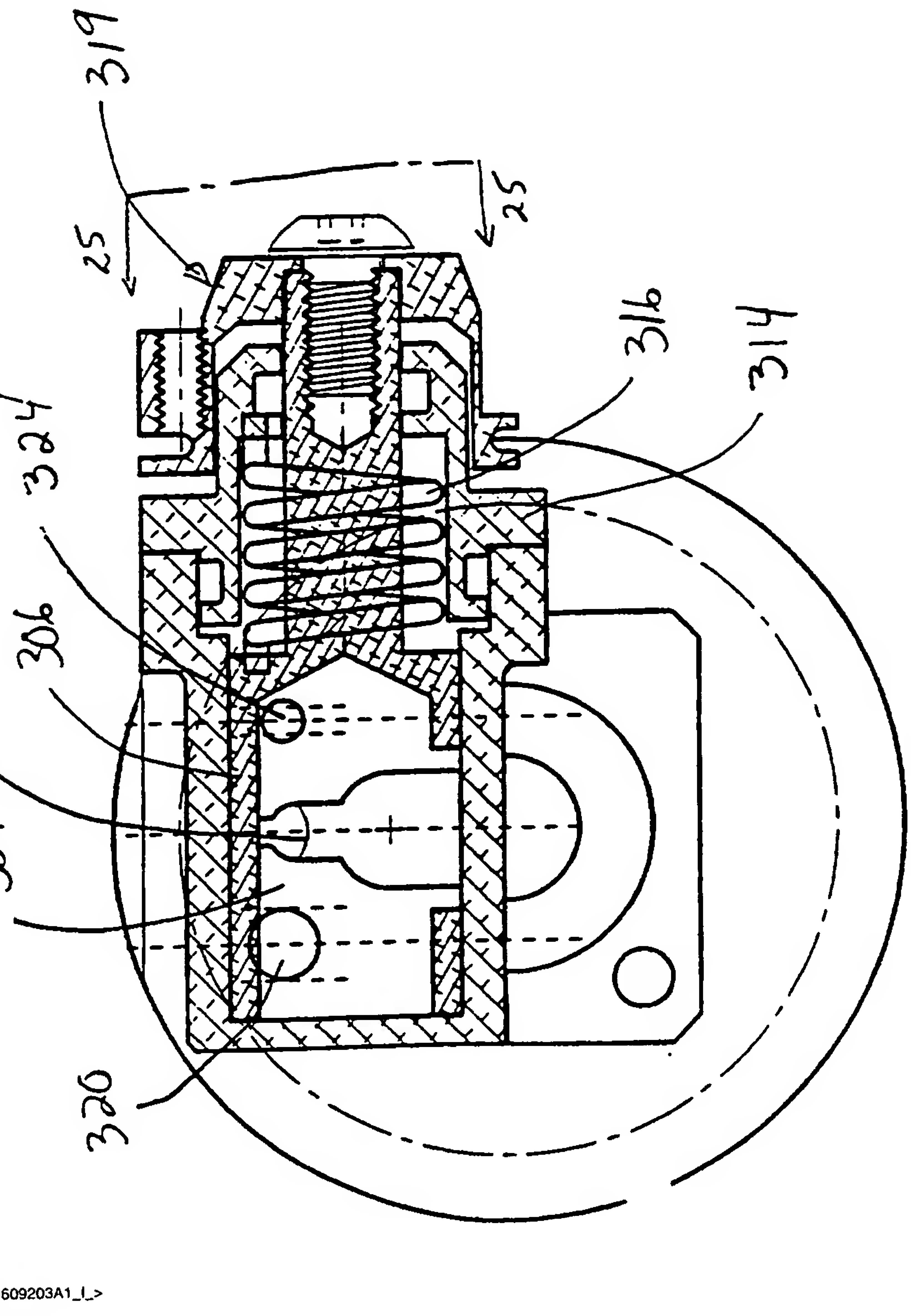

FIG. 24

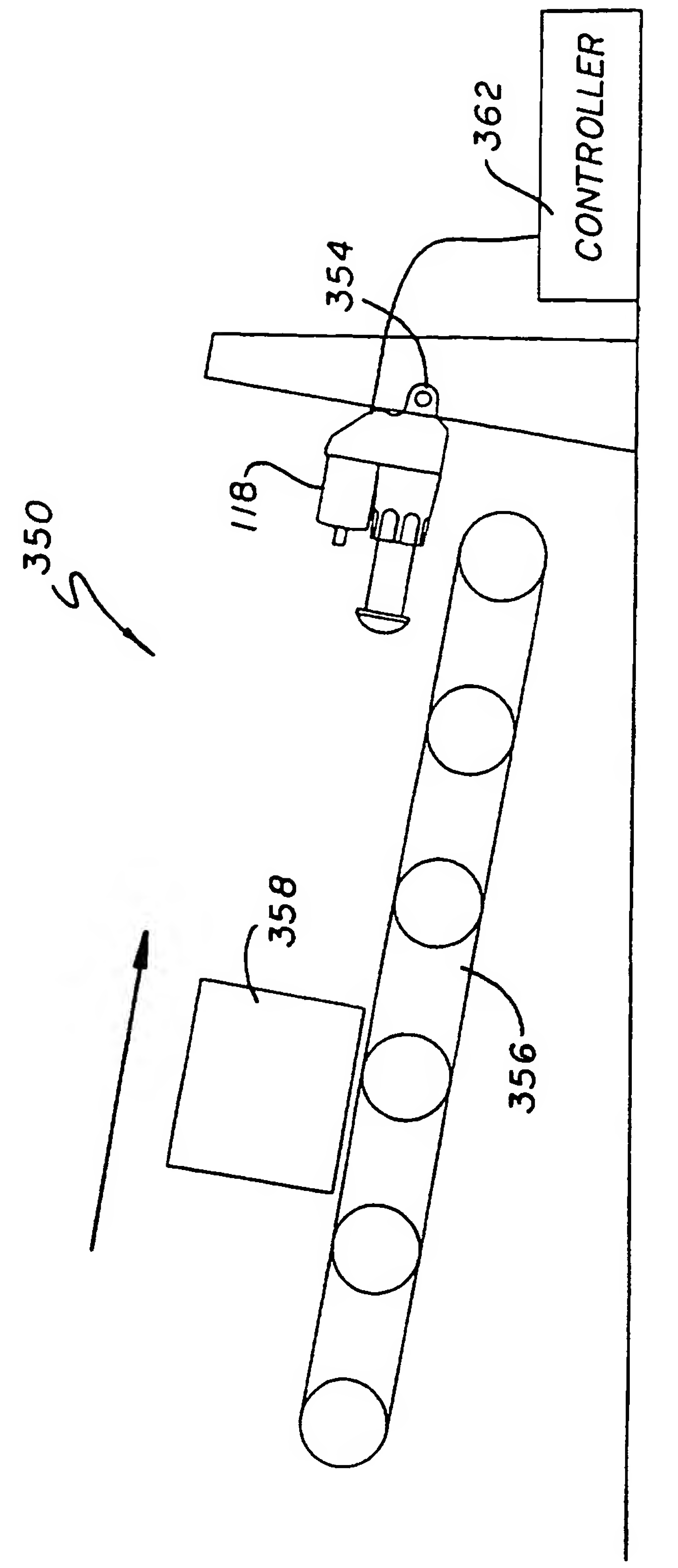

FIG. 27

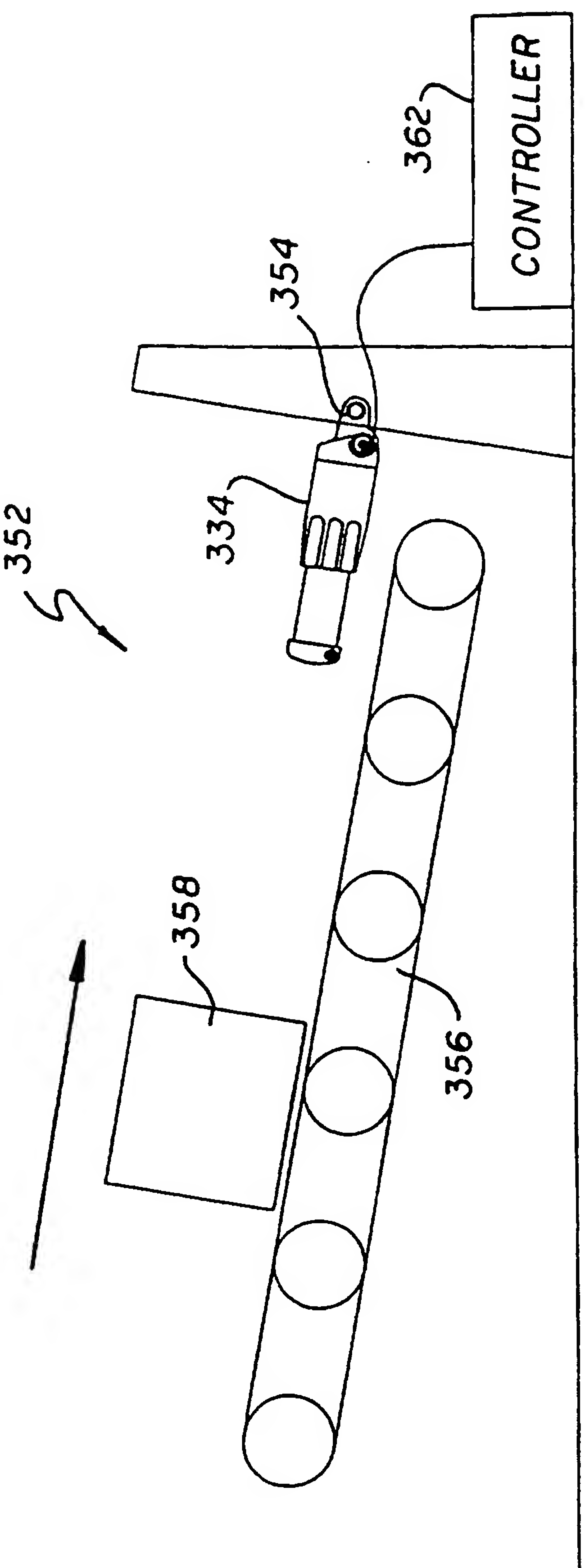

FIG. 28

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11932

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B62K 25/28
US CL : 280/284
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,320,375 (Reeves et al.) 14 June 1994 See Fig. 1	1-35
Y	US, A, 4,660,689 (Hayashi et al.) 28 April 1987 See columns 5-7	1-35
A	US, A 5,409,248 (Williams) 25 April 1995	None
A	US, A, 5,275,264 (Isella) 04 Jan 1994	None
A	US, A, 4,337,850 (Shimokura) 06 July 1982	None

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search 26 NOVEMBER 1995	Date of mailing of the international search report 27 DEC 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Matthew C. Graham Telephone No. (703) 308-2570

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

280/284
280/284,285,286,276,277,275,283
188/300,319,299,285,282